US005410799A

United States Patent [19]

Thomas

[11] **Patent Number: 5,410,799**

[45] **Date of Patent: May 2, 1995**

[54] **METHOD OF MAKING ELECTROSTATIC SWITCHES FOR INTEGRATED CIRCUITS**

[75] Inventor: **Michael E. Thomas,** Milpitas, Calif.

[73] Assignee: **National Semiconductor Corporation,** Santa Clara, Calif.

[21] Appl. No.: **32,615**

[22] Filed: **Mar. 17, 1993**

[51] **Int. Cl.⁶** **H01H 11/00**

[52] **U.S. Cl.** **29/622;** 29/829; 200/181

[58] **Field of Search** 29/622, 829; 200/181

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,927,255	3/1960	Diesel	200/181
3,566,457	3/1971	Engler	29/832
3,681,134	8/1972	Nathanson et al.	29/829
4,320,572	3/1982	Brower et al.	29/622
4,674,180	6/1987	Zavracky et al.	29/622
5,121,089	6/1992	Larson	200/181
5,258,591	11/1993	Buck	200/181

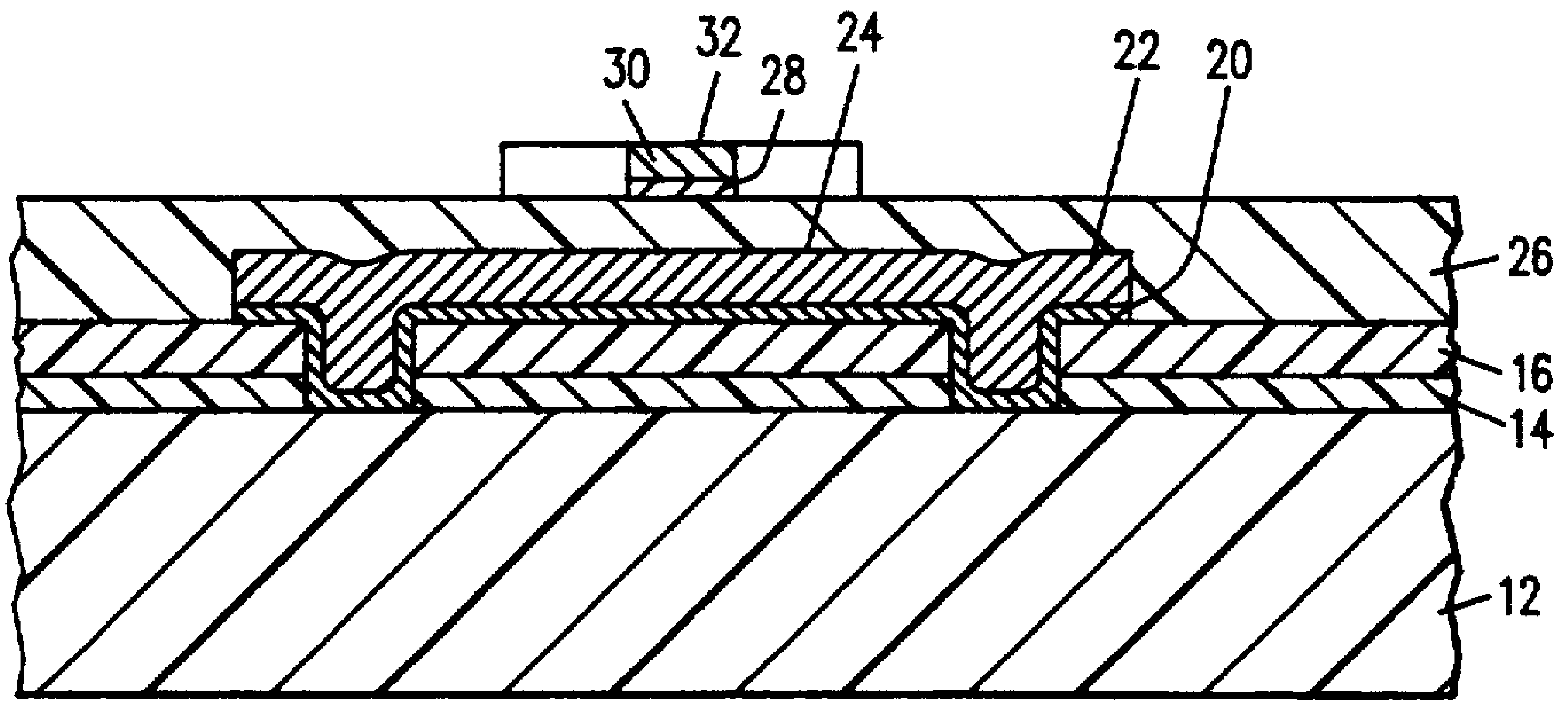
Primary Examiner—P. W. Echols

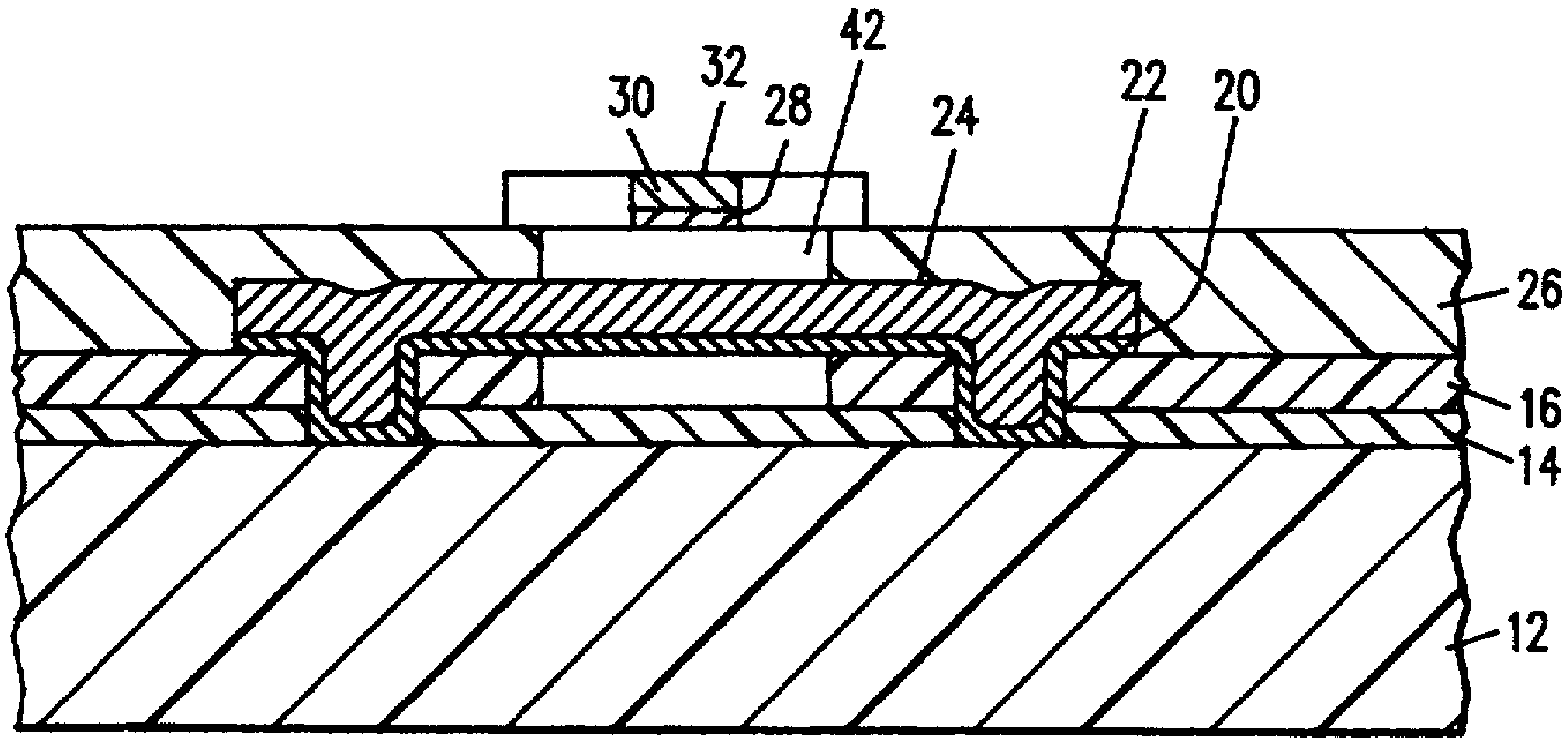
Attorney, Agent, or Firm—Stephen R. Robinson; William H. Murray

[57] **ABSTRACT**

The first electrical switch contact of an electrostatic switch is formed over a substrate. A layer of electrically insulating material is interposed between the first switch contact and the substrate where the substrate is a silicon substrate having active regions. In that case, contact holes are formed in the insulating layer where desired to form electrical contact between the first switch contact and an underlying active region. An electrically insulating layer is formed over the first switch contact. A second switch contact is formed over the electrically insulating layer in a position such that a middle portion of the second electrical contact overlies a middle portion of the first electrical contact. A void is then created between the middle portions of the two electrical contacts by removing a portion of the electrically insulating material there between. The switch is operable by applying an electrical potential between the electrical contacts such that the middle portion of at least one of the electrical contacts deflects toward the middle portion of the other whereby electrical contact is created between the two.

8 Claims, 12 Drawing Sheets





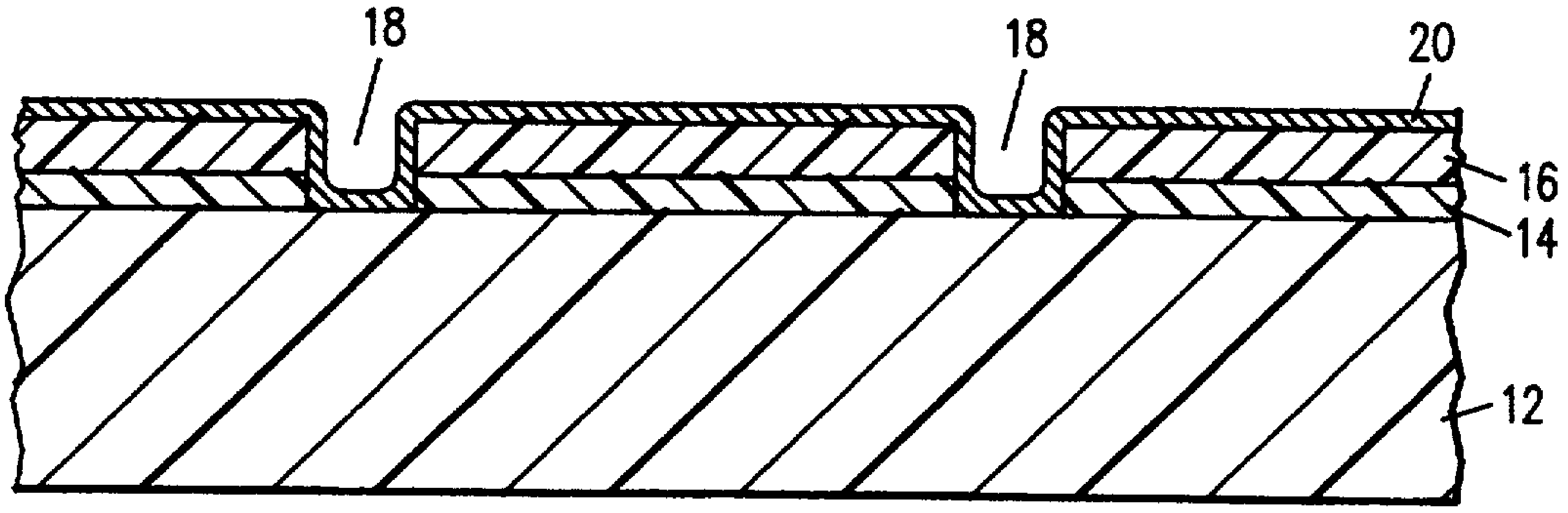


FIG. 1A

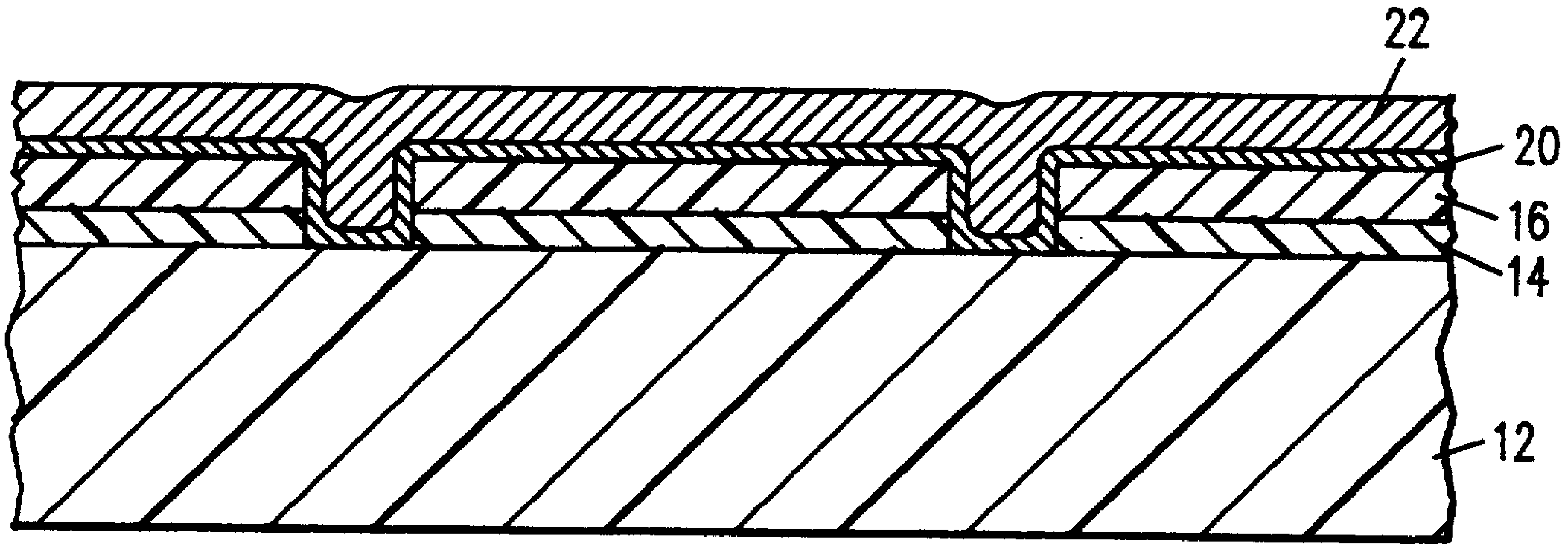


FIG. 1B

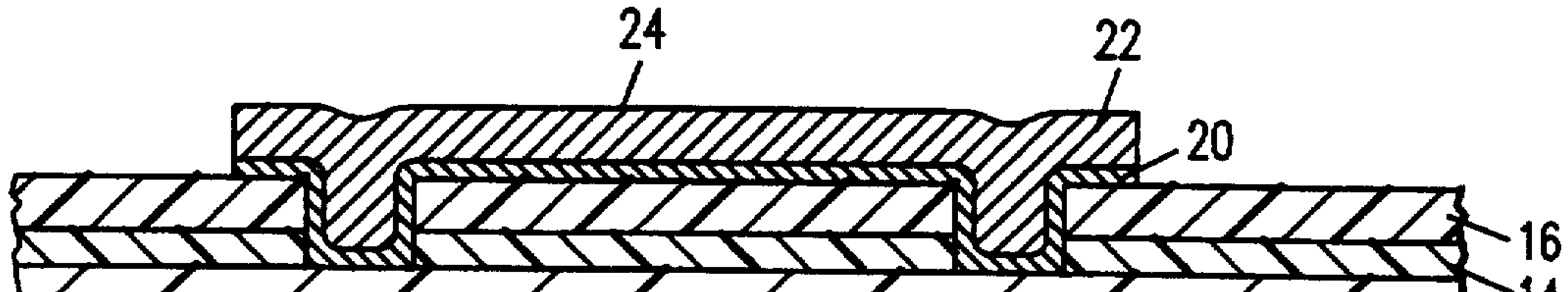


FIG. 1C

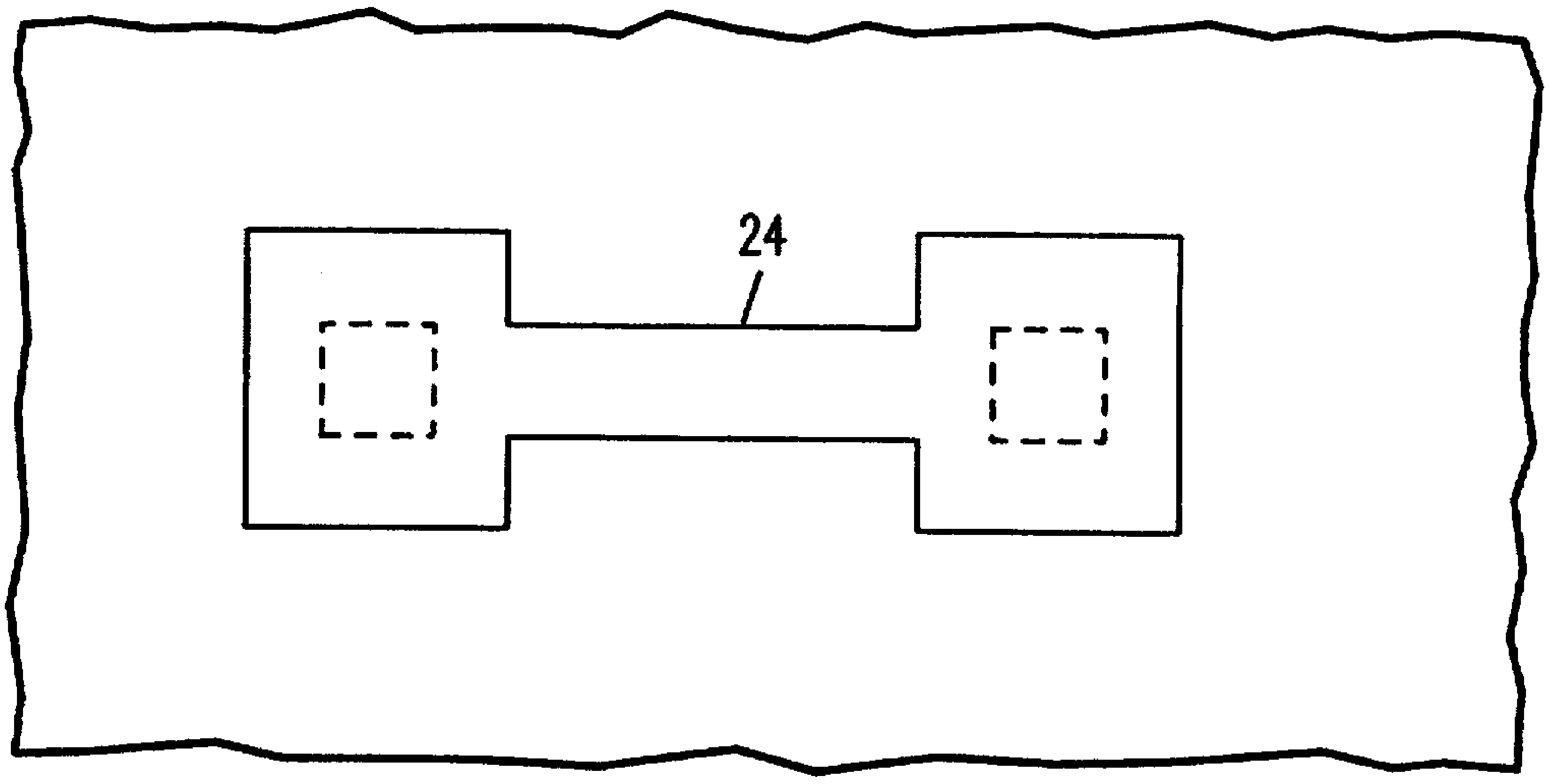


FIG. 1D

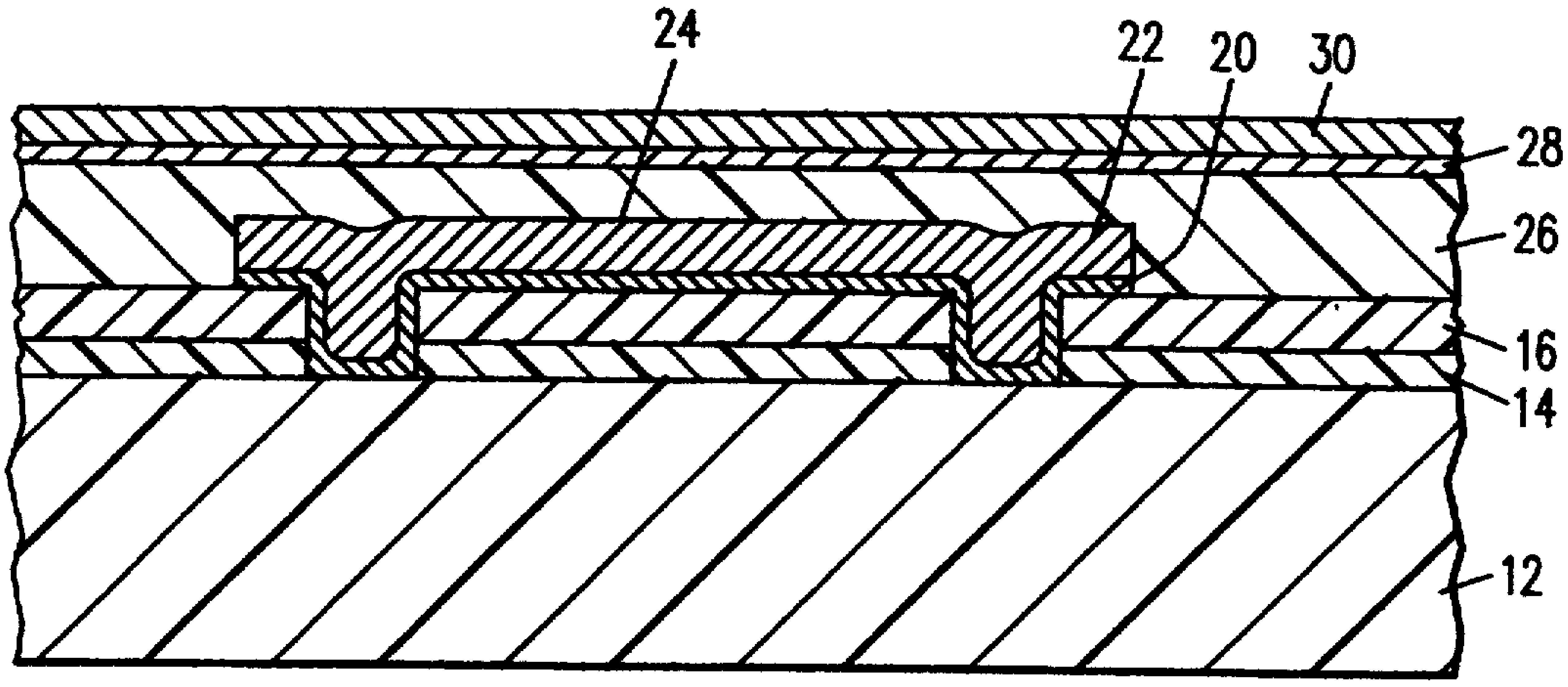


FIG. 1E

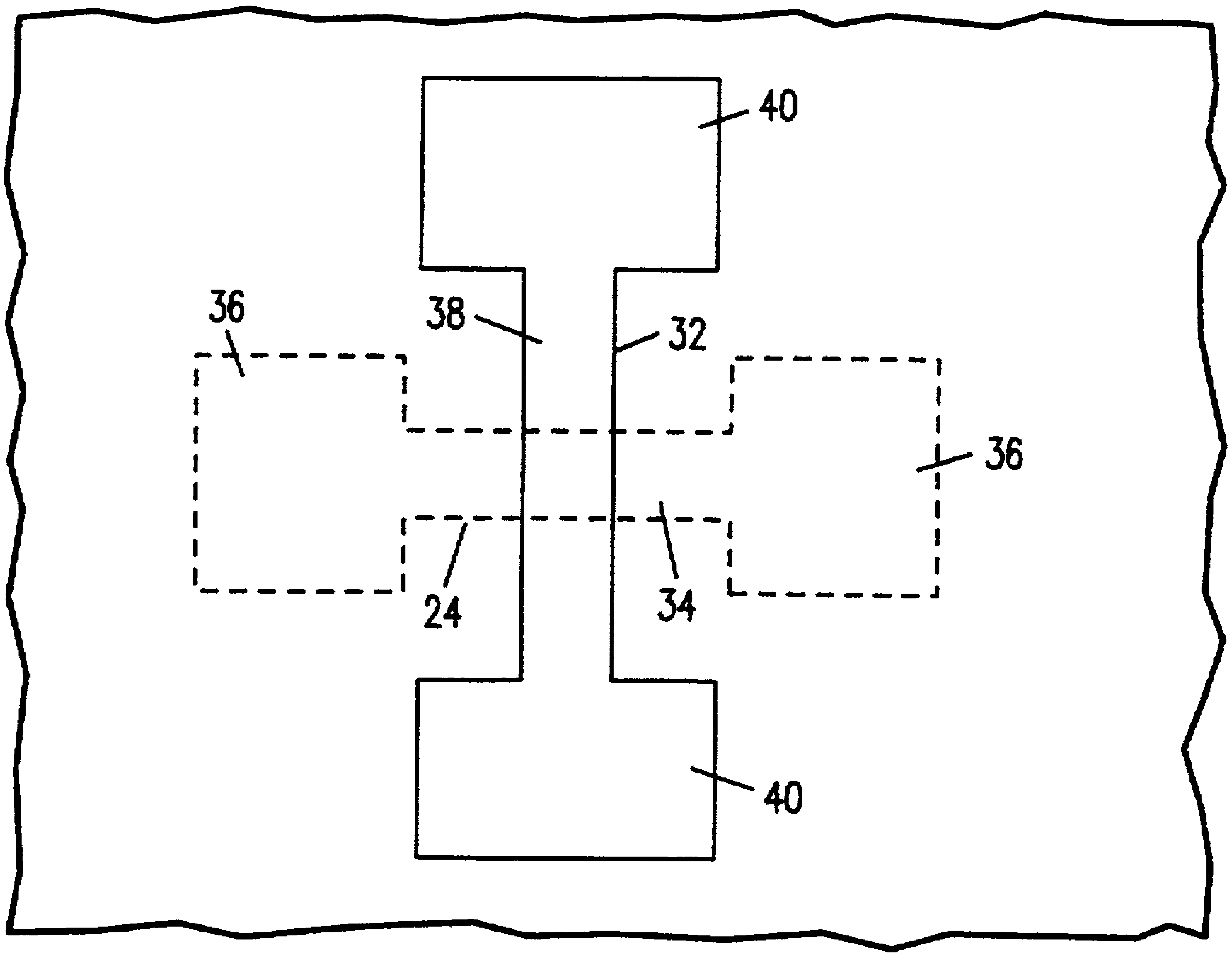


FIG. 1F

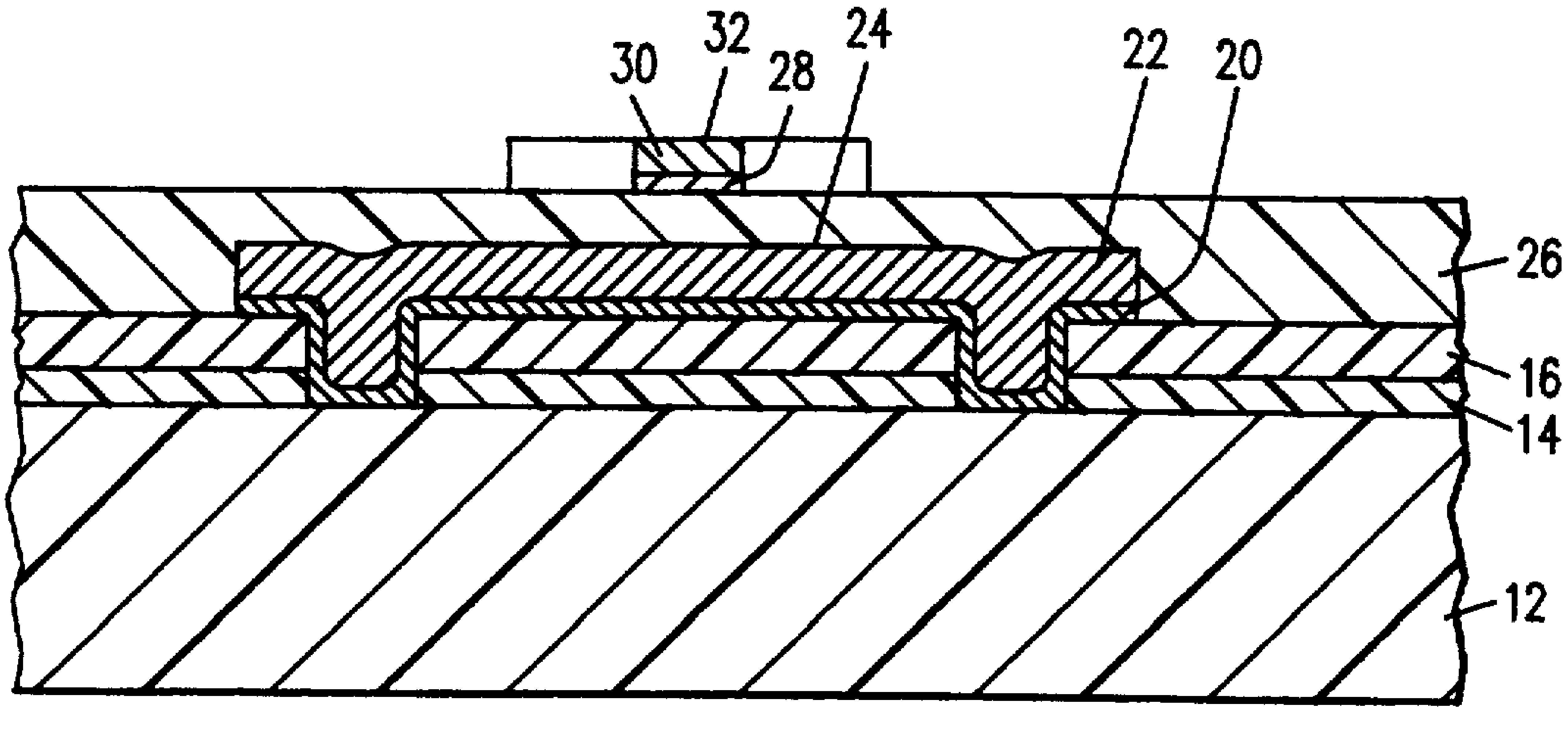


FIG. 1G

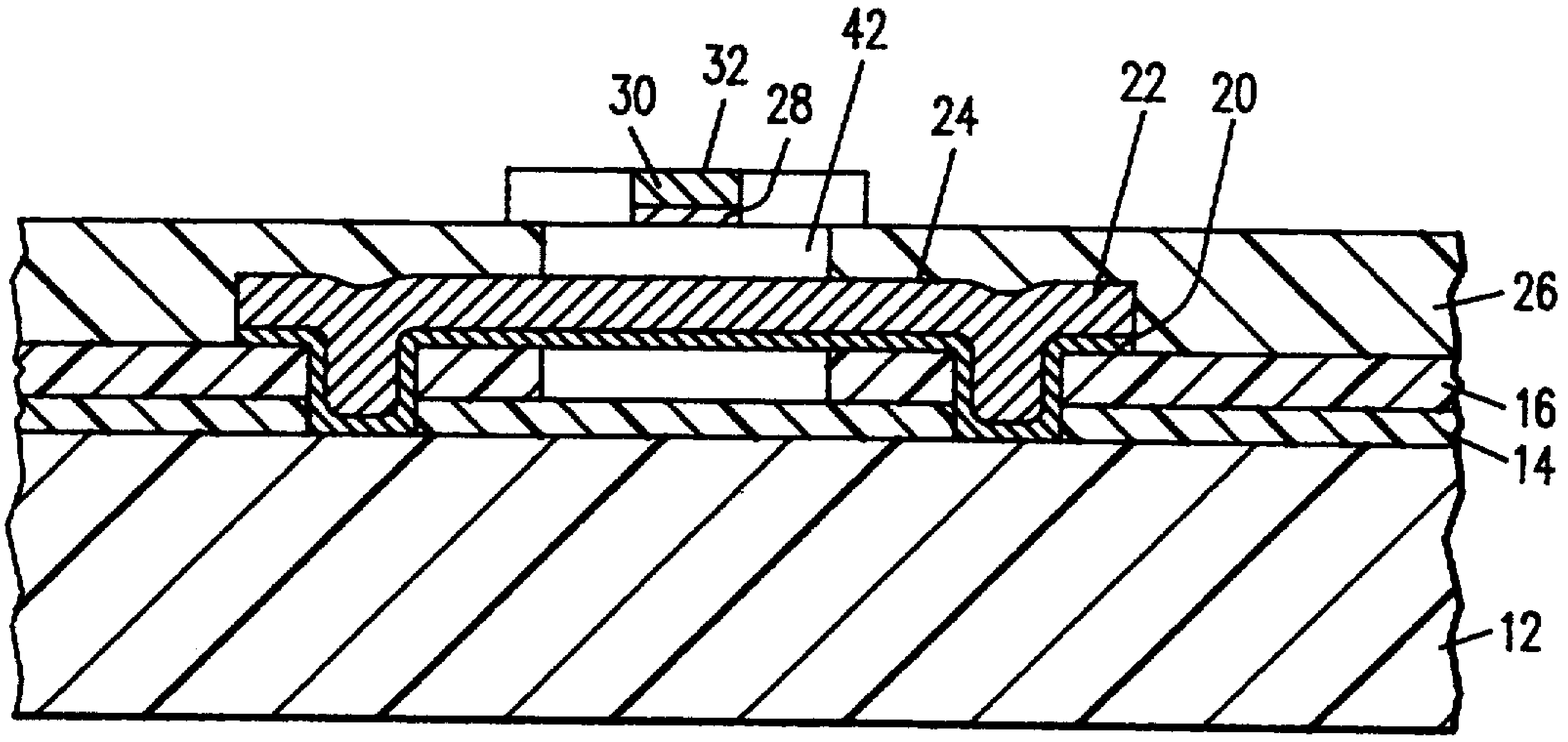


FIG. 1H

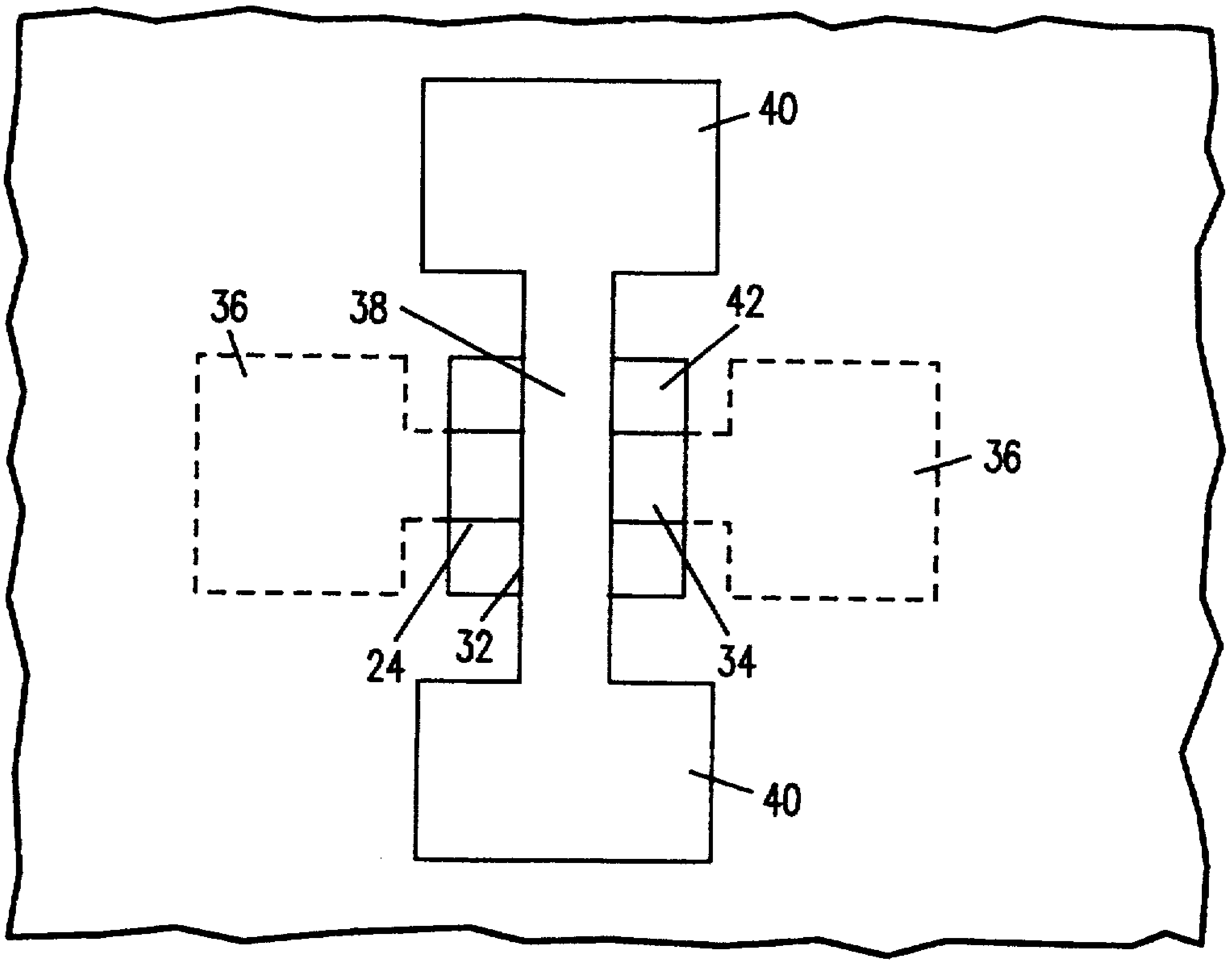


FIG. 1I

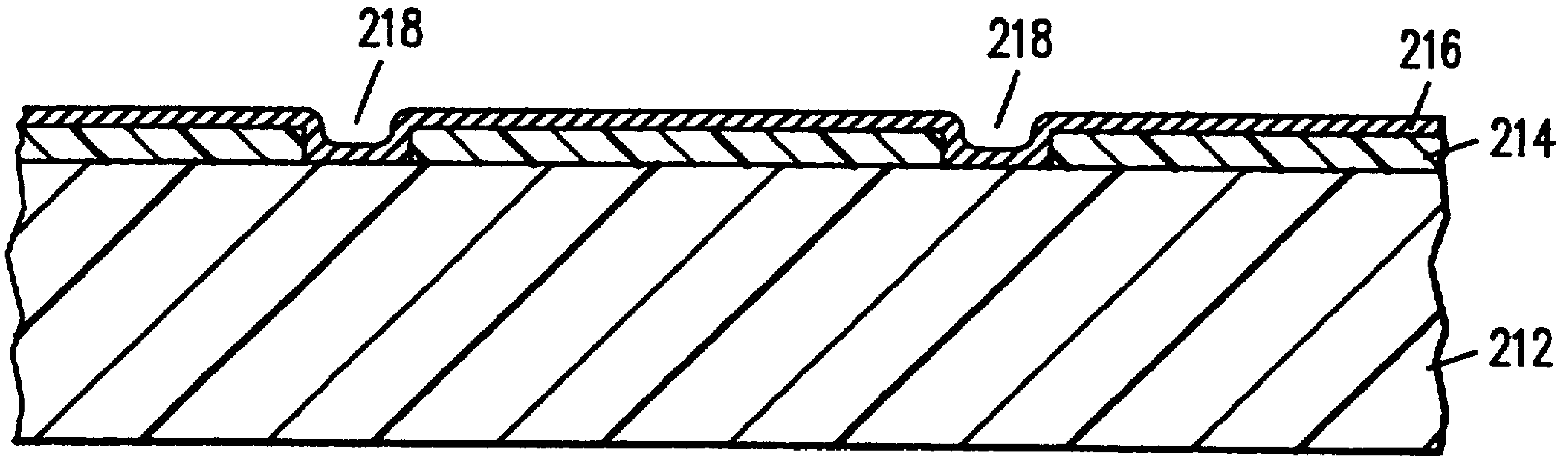


FIG. 2A

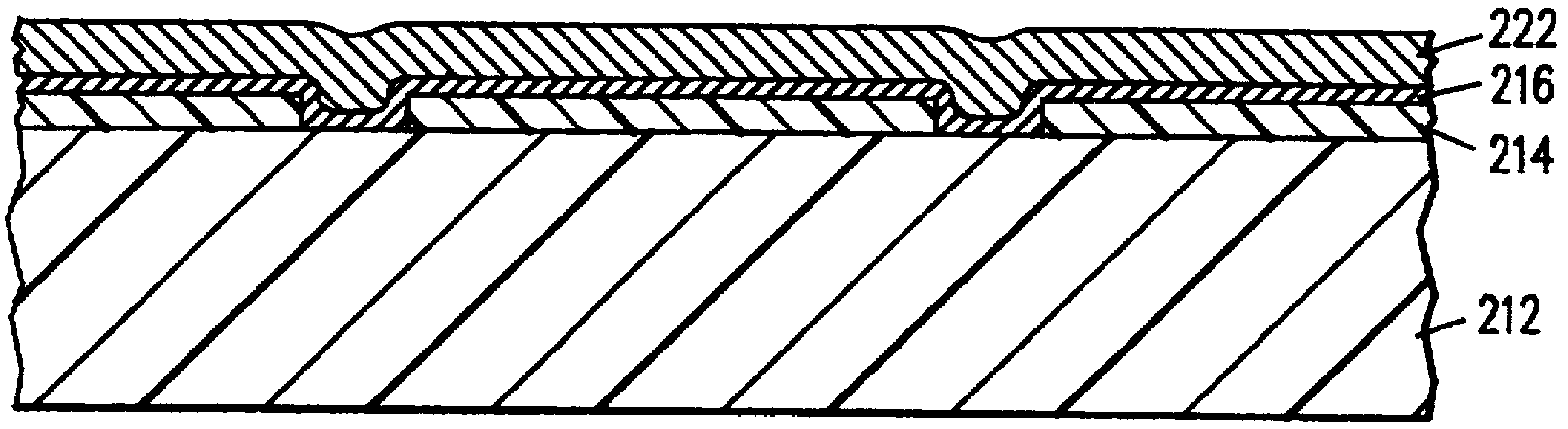


FIG. 2B

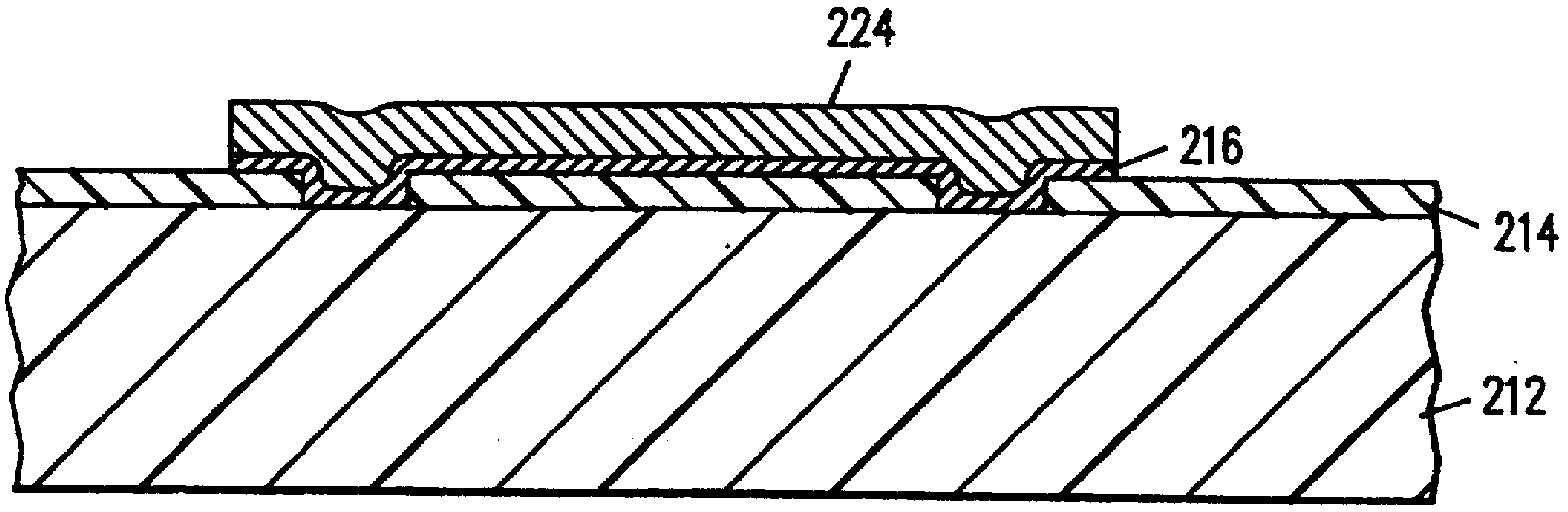


FIG. 2C

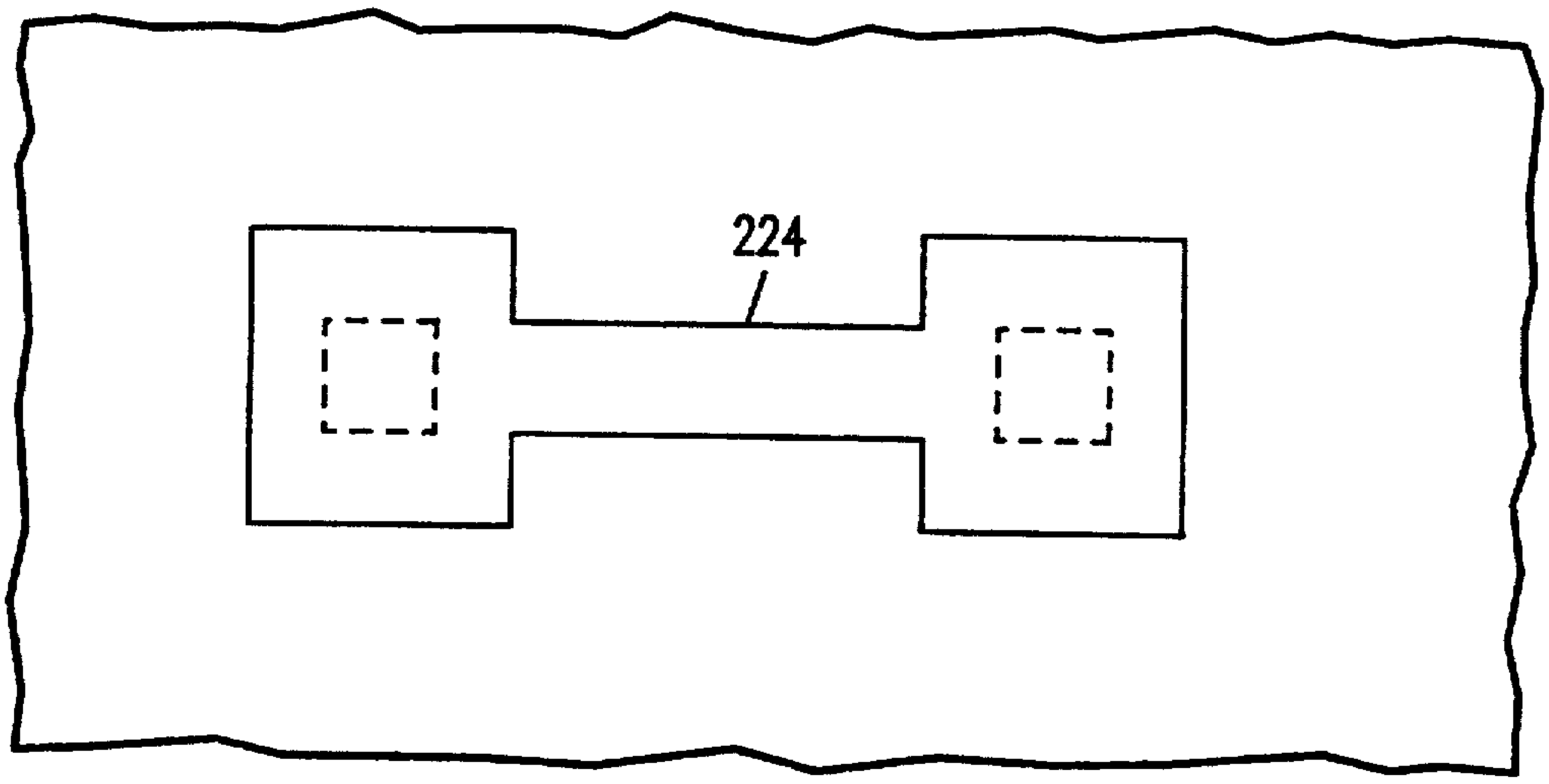


FIG. 2D

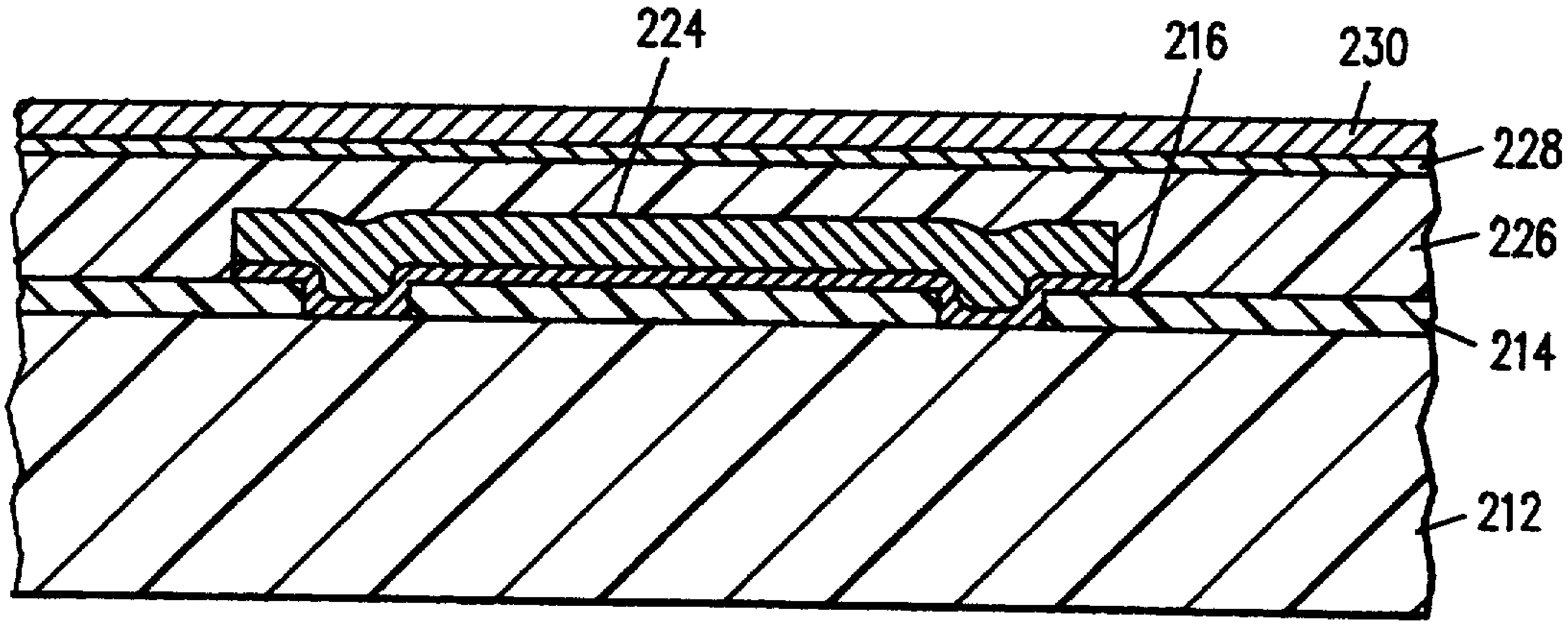


FIG. 2E

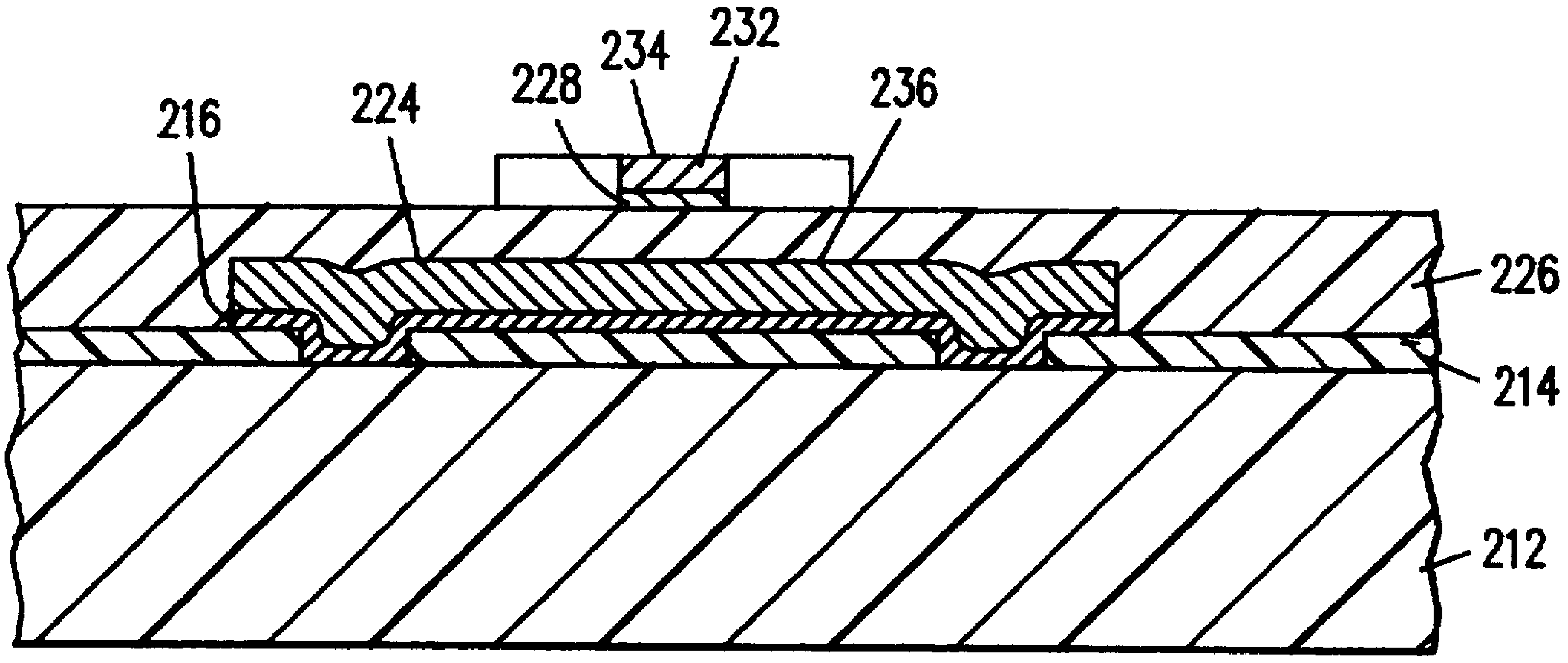

216
224
228
234
232
236
226
214
212

FIG. 2F

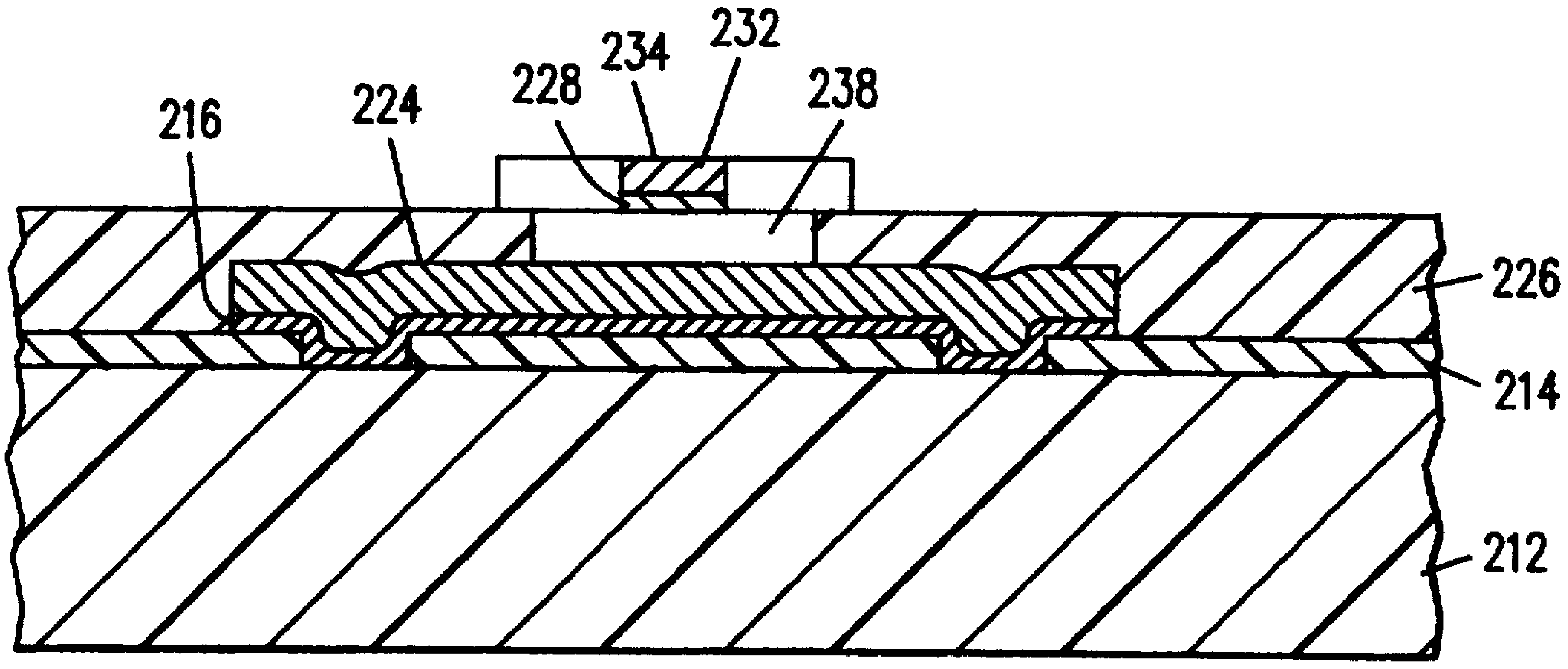

216
224
228
234
232
238
226
214
212

FIG. 2G

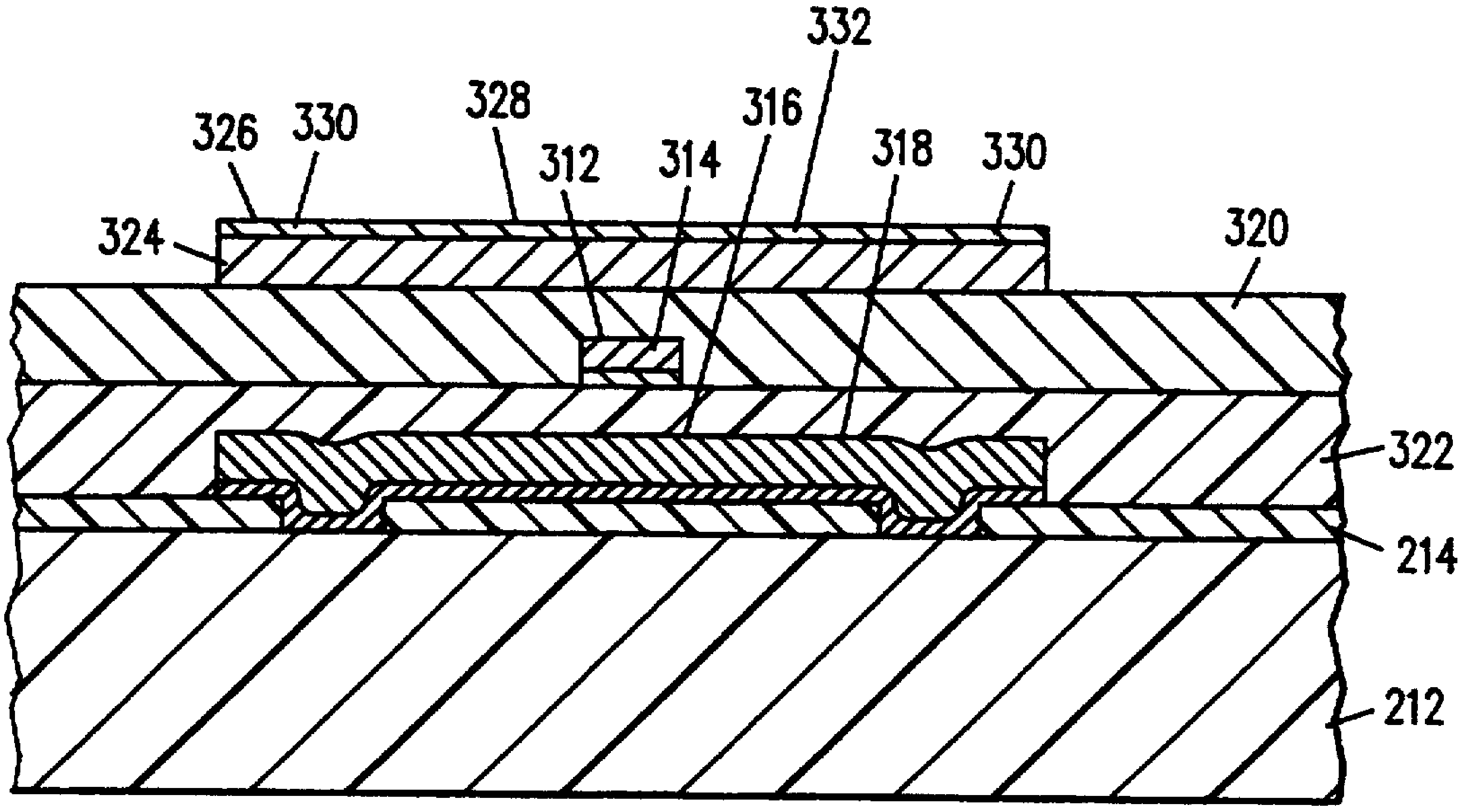

332
328
316
326
330
312
314
318
330
324
320
322
214
212

FIG. 3A

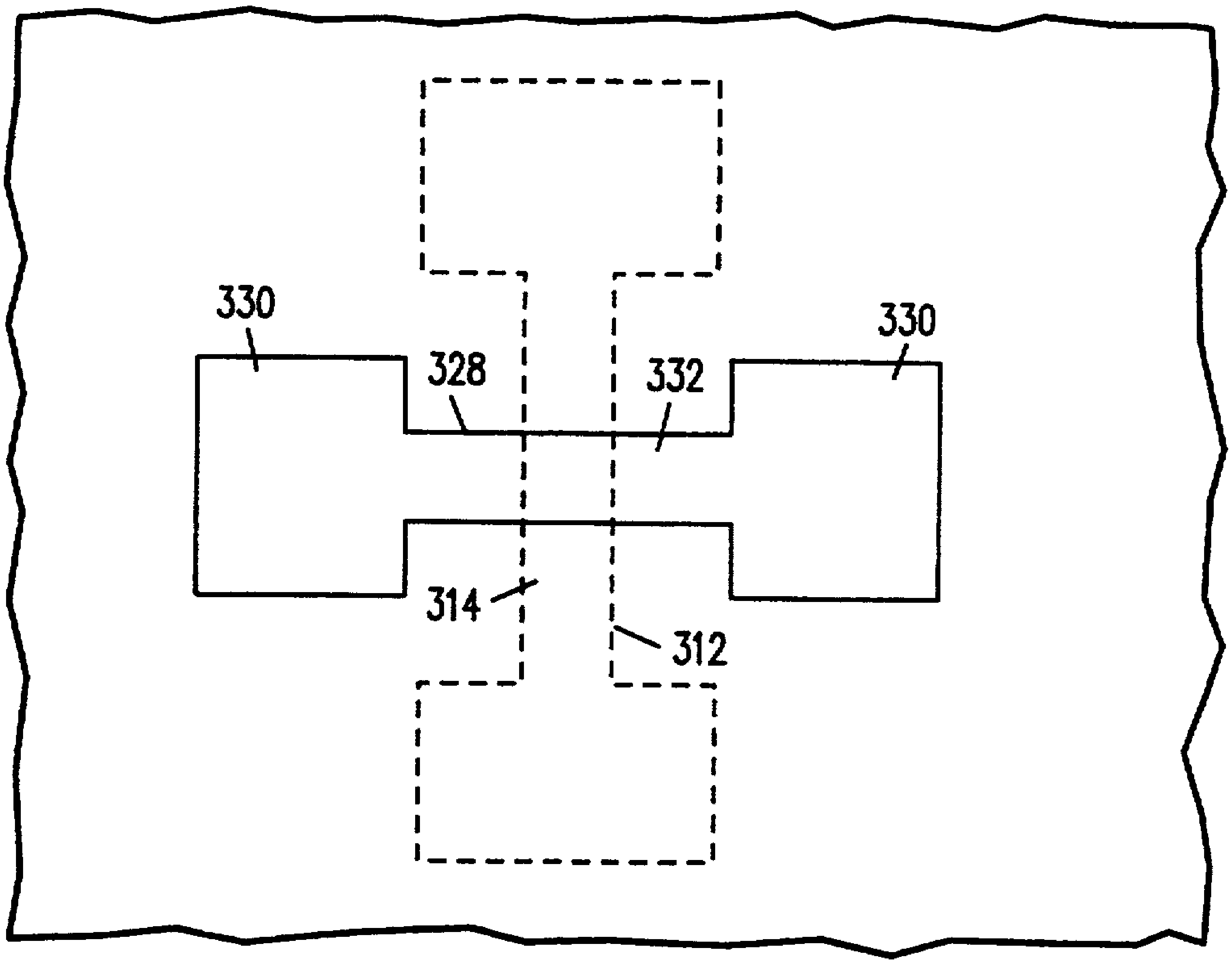

330
330
328
332
314
312

FIG. 3B

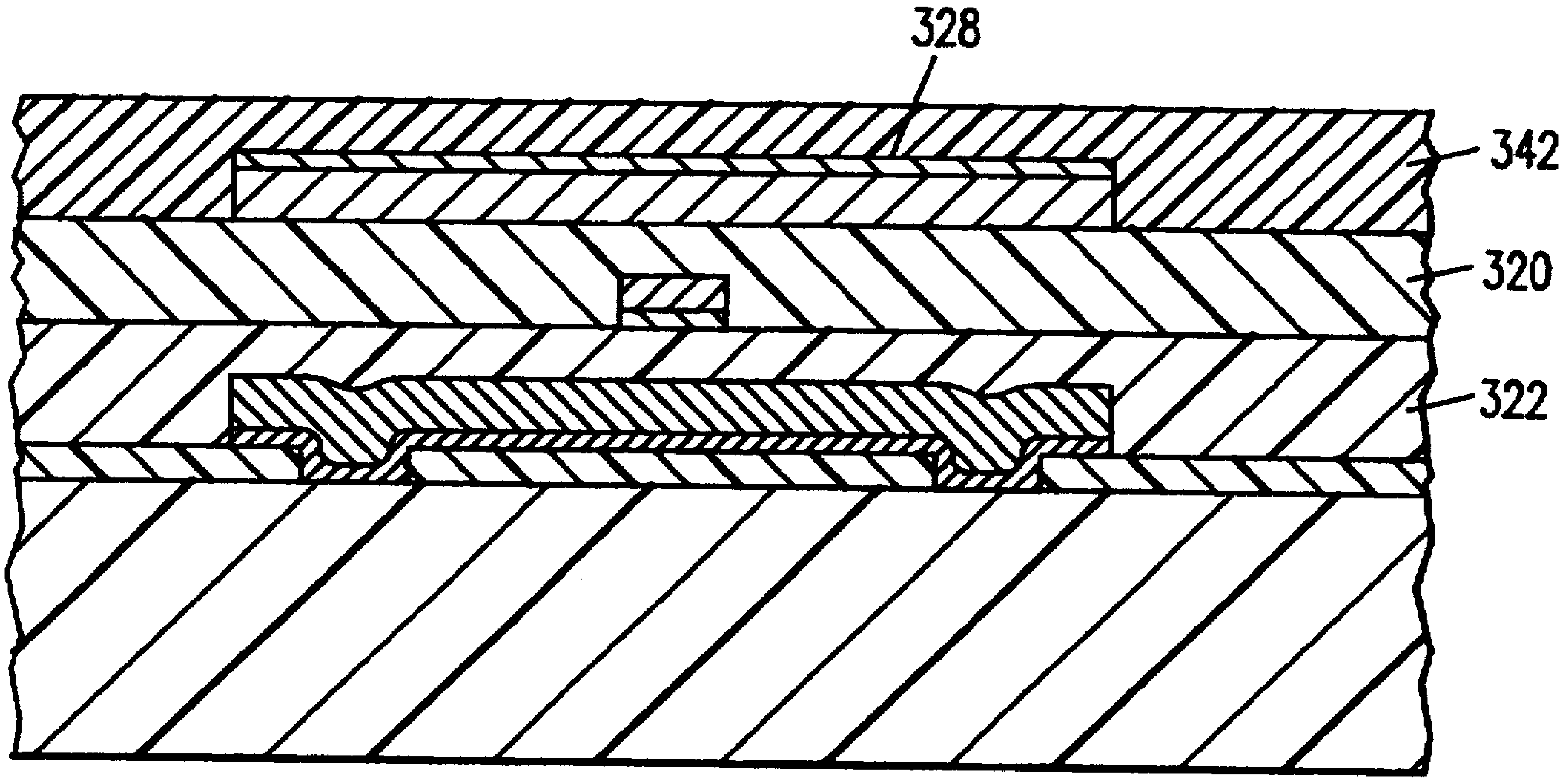


FIG. 3C

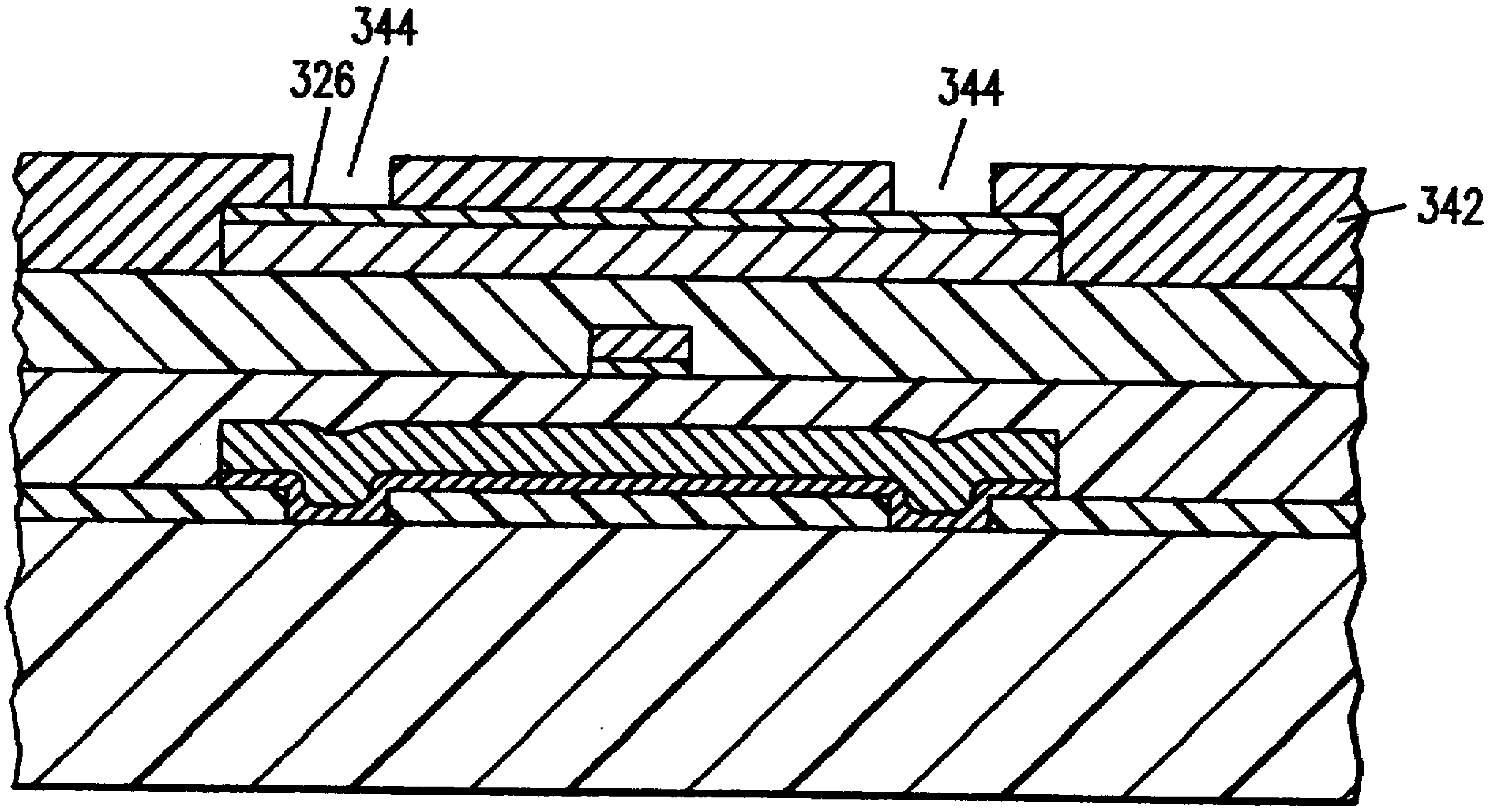


FIG. 3D

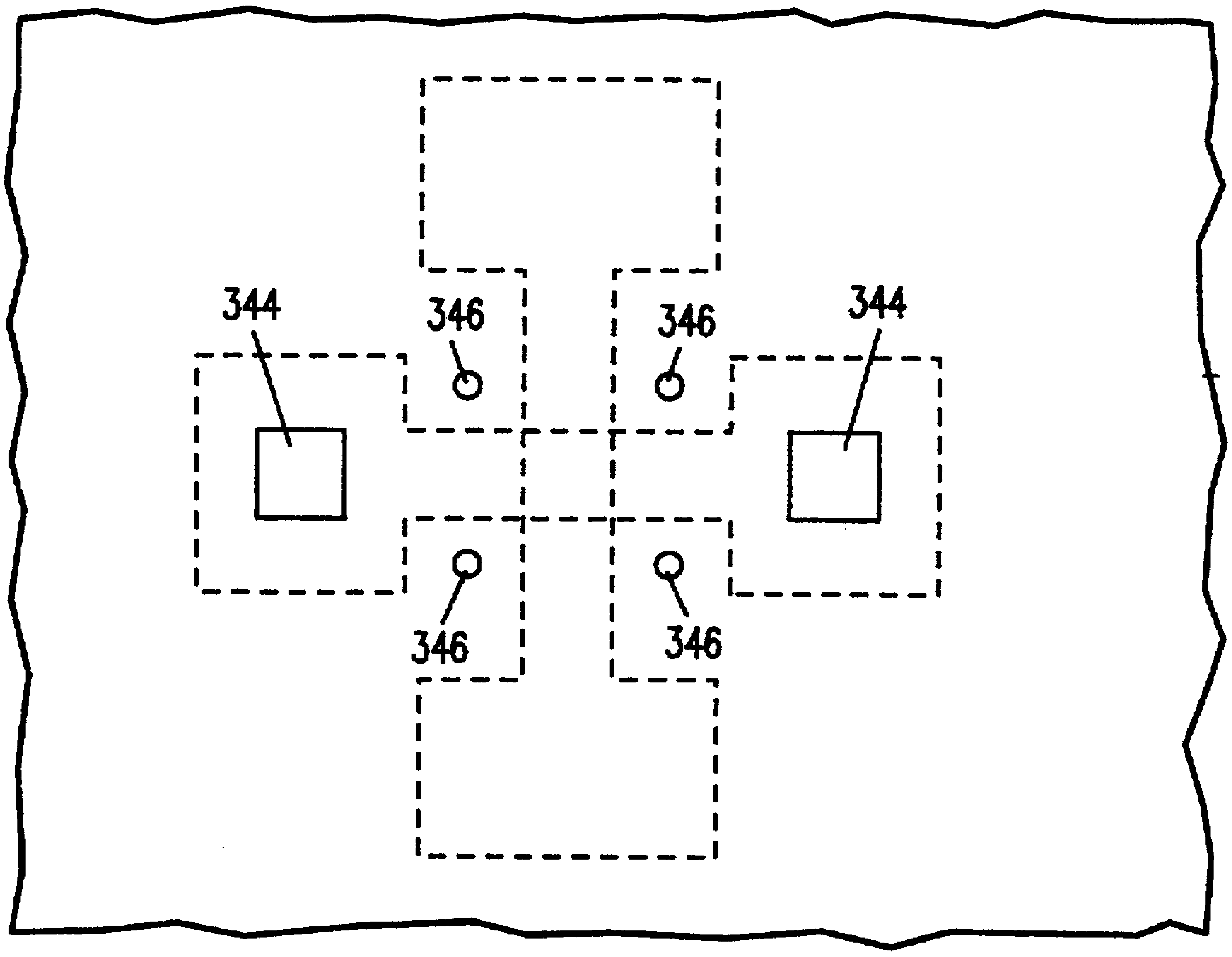

344
346
346
344
346
346

FIG. 3E

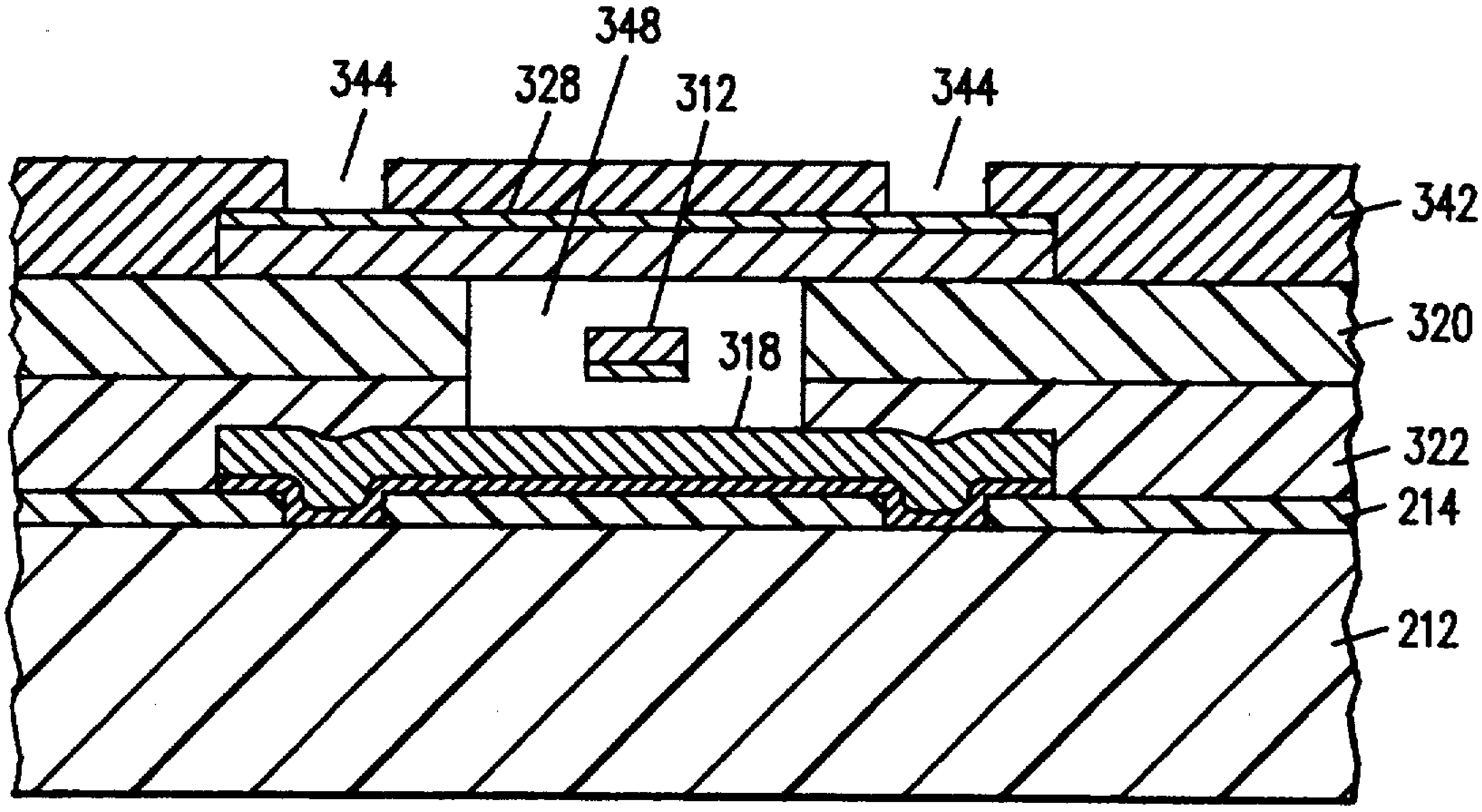

348
344
328
312
344
342
318
320
322
214
212

FIG. 3F

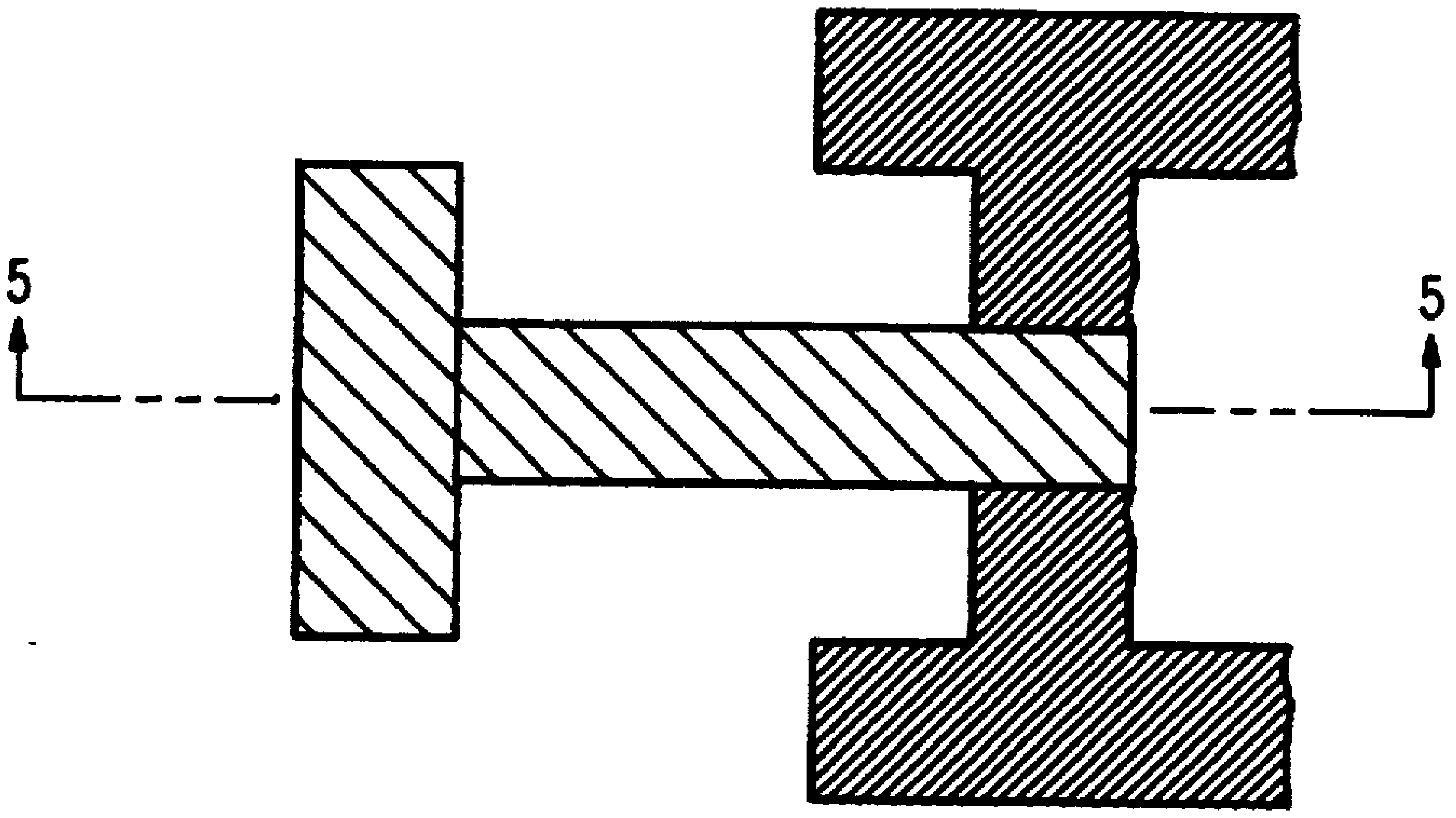


FIG. 4

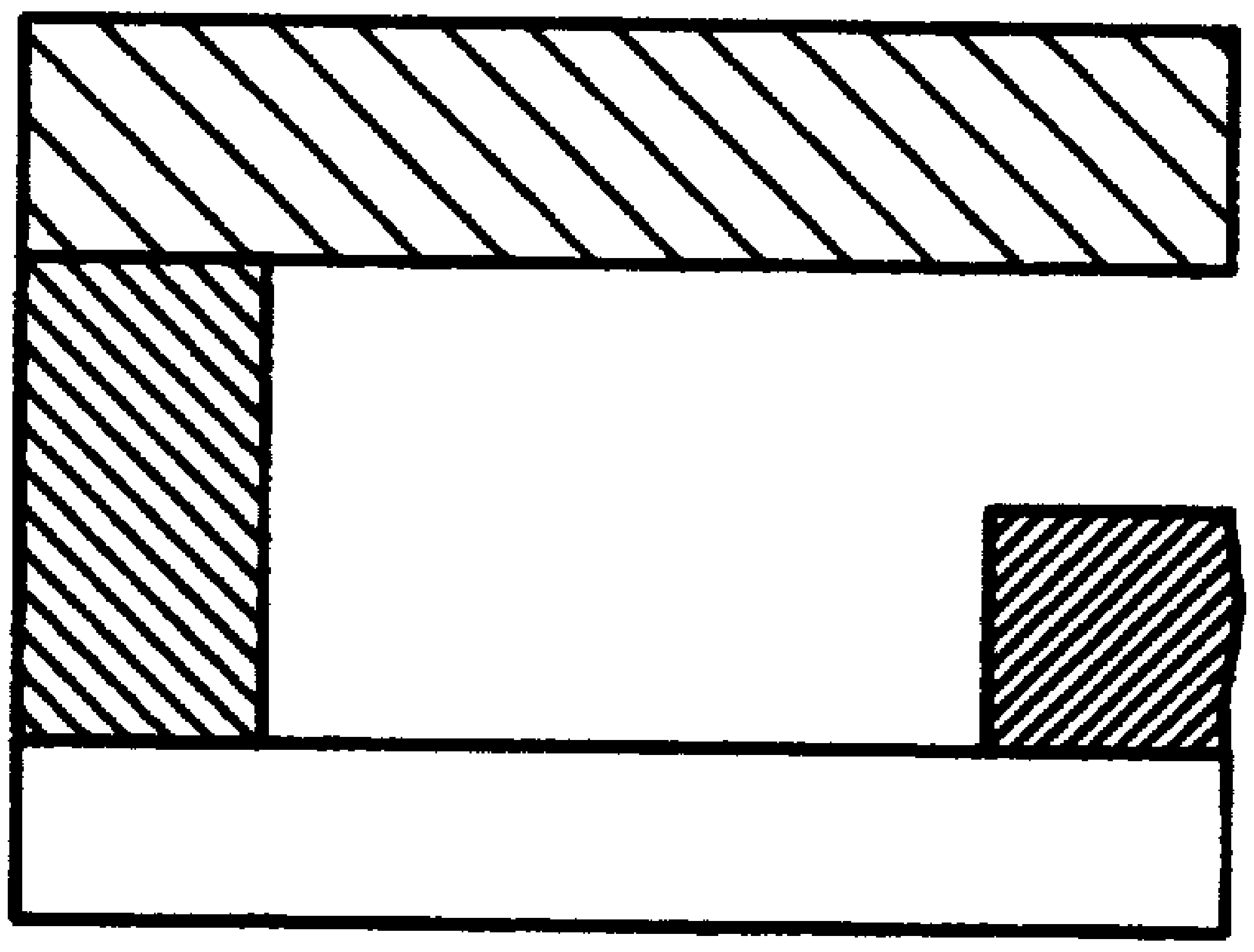


FIG. 5

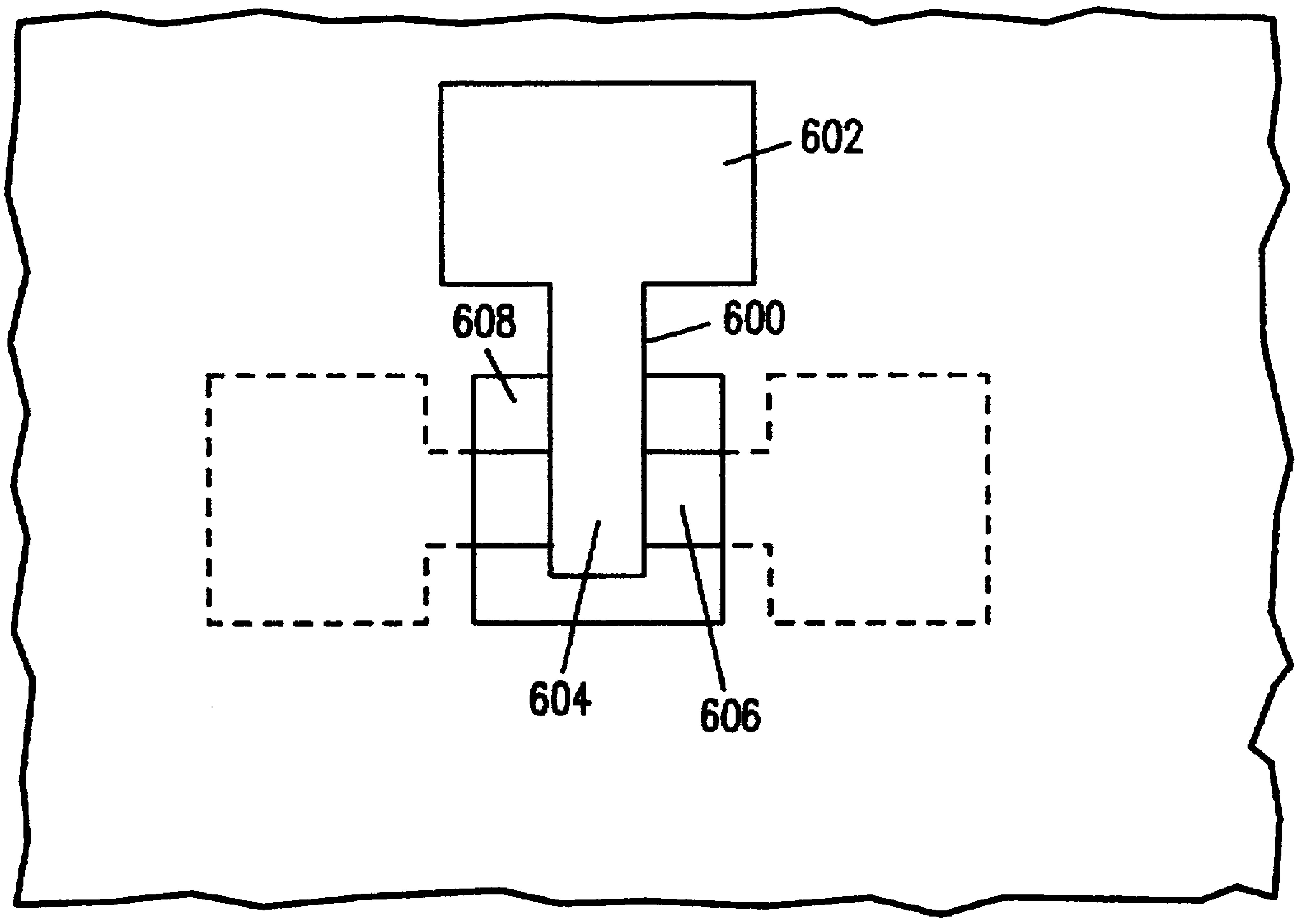


FIG. 6

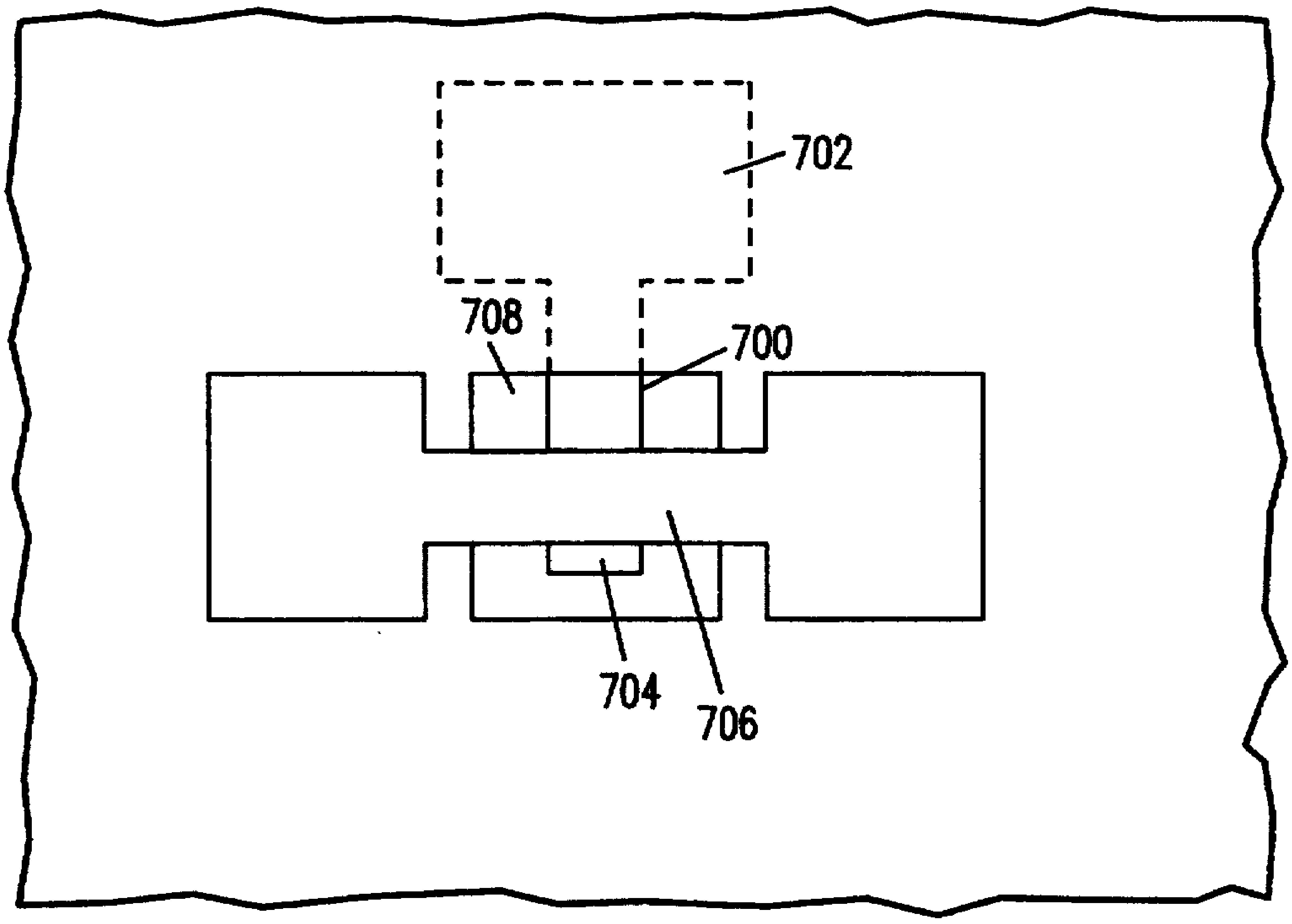


FIG. 7

METHOD OF MAKING ELECTROSTATIC SWITCHES FOR INTEGRATED CIRCUITS

BACKGROUND OF THE INVENTION

This invention relates to integrated circuits and more particularly to electromechanical switches for integrated circuits.

Integrated circuits are typically fabricated with fixed wiring schemes for interconnecting the various integrated circuit devices. Because these wiring schemes are fixed, functional versatility dictates that more devices are required than wold be the case if the electrical connections were programmable. These excess device requirements consume extremely valuable real estate on the integrated circuit. Accordingly, it is desirable to construct a physical interconnect structure on an integrated circuit which allows programmable wiring schemes. Such programmable wiring schemes could also be useable for making programable multi-chip interconnects; trimming links for high precision digital to analog converters and programmable nonvolatile memories among other applications.

SUMMARY OF THE INVENTION

An electrostatic switch for integrated circuits includes a first electrical contact means formed on an integrated circuit. A second electrical contact means, is formed in proximal spaced relationship with respect to the first contact means. An electrical potential is applied between the first and second electrical contact means which causes at least one of the electrical contact means to deflect toward and electrically contact the other electrical contact means as a result of electrostatic forces imparted by the potential difference applied.

In one embodiment, one of the electrical contact means comprises a cantilevered metal strip mechanically attached at one end to the integrated circuit. The unattached end of the metal strip is positioned in proximal spaced relation with respect to the other electrical contact means. Application of the potential difference between the two electrical contact means causes the unattached end of the cantilevered metal strip of the one electrical contact means to deflect toward and into electrical contact with the first electrical contact means as a result of electrostatic forces imparted.

In an alternate embodiment, at least one of the electrical contact means comprises a strip of electrically conductive material which is mechanically attached at both ends to the integrated circuit. At least a portion of the metal strip intermediate the ends is disposed intermediate and spaced from adjacent electrical contact means. Application of the potential difference between the electrical contact means causes the portion of the one electrical contact means intermediate the ends thereof to deflect toward and into electrical contact with the other electrical contact means as a result of the applied electrostatic forces.

Another embodiment takes the form of a single pole double throw switch. In this embodiment, one of the electrical contact means comprises a strip of electrically conductive material which is mechanically attached at both ends to a substrate, preferably the substrate of an integrated circuit. At least a portion of the metal strip intermediate the ends is disposed intermediate and spaced from adjacent electrical contact means. Application of the potential difference between the middle electrical contact means and one of the adjacent electrical contact means causes the portion of the middle electrical contact means intermediate the ends thereof to deflect forward and into electrical contact with the one electrical contact means as a result of the applied electrostatic forces. In this embodiment, the potential applied between the middle electrical contact means and one of the adjacent electrical contact means can also be repulsive in nature thereby causing the middle contact means to deflect away from the one adjacent electrical contact means toward and into contact with the other adjacent electrical contact means.

In yet another alternate embodiment, each of the electrical contact means comprises a strip of electrical conductive material which is mechanically attached at both ends to the integrated circuit but is free to deflect in the middle. At least a portion of the metal strip intermediate the ends of each is disposed in proximal spaced relationship with respect to the other. Application of the potential difference between the electrical contact means causes the portion of each electrical contact means intermediate the ends thereof to deflect toward and into electrical contact with the portion of the other electrical means intermediate the ends thereof as a result of the applied electrostatic forces.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1A** through **1I** depict diagrammatic cross-sectional views of stages of fabrication of a preferred embodiment of an electrostatic switch in accordance with the present invention.

FIGS. **2A** through **2G** depict diagrammatic cross-sectional views of stages of fabrication of an alternate preferred embodiment of an electrostatic switch in accordance with the present invention.

FIGS. **3A** through **3F** depict diagrammatic cross-sectional views of stages of fabrication of a preferred embodiment of a single pole double throw electrostatic switch in accordance with the present invention.

FIG. **4** diagrammatically depicts a top view of a preferred embodiment of an electrostatic switch in accordance with the present invention where one of the electrical contacts is a cantilevered metal strip.

FIG. **5** is diagrammatic cross-section taken along lines **5**—**5** of FIG. **4**.

FIG. **6** depicts a top view of the preferred embodiment of an electrostatic switch in accordance with the present invention where one of the electrical contacts is a cantilevered metal strip which forms the pole of a single pole single throw switch.

FIG. **7** depicts the top view of the alternate preferred embodiment of an electrostatic switch in accordance with the present invention where one of the electrical contacts is a cantilevered metal strip which forms the pole of a single pole double throw switch.

DETAIL DESCRIPTION OF THE INVENTION

Referring to FIGS. **1A** through **1H** there is shown, in diagrammatic cross-sectional view, various stages of fabrication of an electrostatic switch for integrated circuits in accordance with a preferred embodiment of the present invention. An etch stop layer **14** is formed over a silicon substrate **12**. In the preferred embodiment, the etch stop layer **14** comprises silicon nitride which formed preferably by a CVD process as is known in the art, preferably to a thickness of approximately 1 micron. An electrically insulating layer **16** is formed over the layer **14**. In the preferred embodiment, the electrically insulating layer **16** comprises silicon dioxide which is preferably formed by a CVD process as is known in the art, to a thickness which is preferably approximately 5,000 Å. Contact holes **18** are formed through the layers **16** and **14** to expose underlying contact areas on the silicon substrate. The contact holes **18** are defined by conventional photoresist techniques and are opened through the layers **16** and **14** using an etchant which, in the preferred embodiment, is a dry fluorinated plasma for example CHF_3 and oxygen.

Although the following detailed description is directed to embodiments where the electrostatic switches are fabricated on a semiconductor substrate having active regions which are accessed through contact holes, it is within the scope and contemplation of the present invention to fabricate the electrostatic switches on any type of rigid substrates such as, for example, silicon or printed circuit board material. In such embodiments where the substrate is an electrically insulating material, it would not be necessary to utilize the electrically insulating layer **16**.

A thin electrically conductive adhesion layer **20** is formed over the upper surface of the layer **16** into the contact holes **18** making electrical contact with the exposed contact areas on the substrate **12**. In the preferred embodiment, the adhesion layer comprises a titanium tungsten alloy which is formed by sputtering as is known in the art to a thickness preferably of approximately 200 Å.

Referring now to Figure **1B**, a layer **22** of electrically conductive material is formed over the adhesive layer **20** into the contact holes **18**. In the preferred embodiment, the electrically conductive layer **22** comprises tungsten which is preferably formed by a CVD process as is known in the art to a thickness, preferably of approximately 5,000Å. It should be noted that the adhesion layer is not necessary if the deposition technique utilized generates sufficient adhesion of the conductive layer 22 to the dielectric layer **16**. This would simplify the structure by eliminating the adhesion layer and such a structure is deemed to be within the scope and contemplation of the present invention.

The electrically conductive layer **22** is patterned and etched as shown in FIGS. **1C** and **1D** using conventional photoresist techniques to form a first switch contact **24**. The etchant is preferably an SF_6 and argon dry etch if the features are very small and H_2O_2 and water for larger features which can tolerate isotropic etching. Such etchants etch the tungsten material of the electrically conductive layer **22** and the titanium tungsten alloy material of the adhesion layer **20** but will stop on the silicon dioxide layer **16**.

Referring to FIG. **1E**, an interlevel dielectric layer **26** is disposed over the electrically insulating layer **16** and the first switch contact **24**. In the preferred embodiment, the first interlevel dielectric comprises silicon dioxide which is preferably formed by a CVD process as is known in the art to a thickness in the range of 500 Å to 20,000 Å, preferably 500 Å.

Following deposition and levelling of the interlevel dielectric layer **26**, a second adhesion layer **28** is formed over layer **26**. In the preferred embodiment, the second adhesion layer **28** comprises a titanium-tungsten alloy which is preferably formed by sputtering as is known in the art to a thickness which is preferably 200 Å. A second layer **30** of electrically conductive material is formed over the second adhesion layer **28**. In the preferred embodiment, the second electrically conductive layer **30** comprises tungsten which is formed, preferably via a CVD process, to a thickness which is preferably approximately 5,000 Å.

As previously stated, the adhesion layer **28** is interposed between layers **26** and **30** when using a CVD process. As also previously stated, it is possible, as is known in the art, to put down conductive films on a dielectric with good adherence. In such cases, an adhesion layer is not necessary which would then eliminate the need for layers **20** and **1** or **28** FIG. **1**. The second electrically conductive layer **30** is formed into a second switch contact **32** as shown in FIGS. **1F** and **1G** using conventional photoresist techniques and an etchant which etches the materials of the second electrically conductive layer **30** and second adhesion layer **28** but etches the material of the interlevel dielectric layer **26** much more slowly as is known in the art.

In the preferred embodiment of the present invention depicted in FIGS. **1F** and **1G**, each contact of the electrostatic switch is substantially in the shape of a dumbbell (sometimes referred to as a dog bone). The first switch contact **24** comprises a strip **34** of the first metal which expands out to contact areas **36** at each end. The second switch contact **32** comprises a strip **38** of the second metal which expands out to contact areas **40** at each end.

Referring now to FIGS. **1H** and **1I**, a void **42** is formed in the interlevel dielectric layer **26** and electrically insulating layer **16** using conventional photoresist and etch techniques. In the preferred embodiment, the etchant is either 10:1 water to HF or buffered oxide etch which attacks the silicon dioxide material of the layers **26** and **16** but is substantially unreactive with the material in the electrically conductive and adhesion layers of the first **24** and second **32** switch contacts.

Referring now to FIGS. **2A** through **2G** there is shown, in diagrammatic cross-sectional view, various stages of fabrication of an electrostatic switch for integrated circuits in accordance with an alternative preferred embodiment of the present invention. In the preferred embodiment described above in connection with FIGS. **1A** through **1H**, the strip portion of each of the switch contacts is floating since it is not supported by surrounding material. In the alternate preferred embodiment which will be described in connection with FIGS. **2A** through **2G** only the strip portion of the second contact is floating since the strip portion of the first contact is supported by and rigidly attached to the etch stop layer formed over the substrate as will be described.

Referring now to FIG. **2A**, a first electrically insulating layer **214** is formed over the substrate **212**. The material of the first electrically insulating layer **214** is PREFERABLY SILICON NITRIDE and the process by which it is formed over the substrate **212** is the same as that described previously in connection with the first embodiment where the electrically insulating layer **214** is formed directly on the surface of the substrate **212**. Contact holes **218** are formed in the first electrically insulating layer **214** to expose contact areas on the underlying substrate **212**. In the preferred embodiment, the contact holes **218** are formed as were the contact holes **18** in the previous description of the other preferred embodiment. The materials and processes used in the remaining portion of this detailed description of the alternate preferred embodiment are the same as comparable materials and processes described in connection with the previously described embodiment.

A first adhesion layer **216** is formed over the first etch stop layer **214** into the contact holes **218** and in electrical contact with the underlying contact areas of the substrate **212**. As shown in FIG. 2B, a first electrically conductive layer **222** is formed over the first adhesion layer **216**. The first electrically conductive layer **222** and first adhesion layer **216** are formed into a first switch contact **224** as shown in FIGS. 2C and 2D.

Referring to FIG. 2E, a layer **226** of dielectric material is formed over the first switch contact **224** and the first etch stop layer **214**. In the preferred embodiment, the electrically insulating layer **226** comprises silicon dioxide. A second adhesion layer **228** and a second electrically conductive layer **230** are formed over the dielectric layer **226**. As noted above, with respect to the description of the previous embodiment, the use of adhesion layers **216** and **228** are preferred when using CVD processing.

Referring now to FIG. 2F, the second adhesion **228** and electrically conductive **230** layers are formed into a second switch contact which has a middle portion **234** which in a preferred embodiment is in substantially orthogonal overlying relationship with the middle portion **236** of the first switch contact **224** as shown, for example, in FIG. 1F. It should be noted that it is not necessary that the overlying relationship be orthogonal. The switch contacts can have any predetermined angular relationship between them from parallel to orthogonal.

Referring now to FIG. 2G, a void **238** is formed in the electrically insulating layer **238** using conventional photoresist and etch techniques as were previously described in connection with the embodiment described above. The void **238** is located under the middle portion **234** of the upper switch contact **236** and is oriented with respect to the upper switch contact **232** as shown, for example, in FIG. 1I

Referring now to FIGS. 3A through 3F, there is shown, in diagrammatic cross-sectional view, various stages of fabrication of a single pole double throw electrostatic switch for integrated circuits in accordance with a preferred embodiment of the present invention. A middle switch contact **312** (the pole in this embodiment) is formed having a middle portion **314** which is in substantially orthogonal overlying relationship with respect to a middle portion **316** of a lower switch contact **318** as described in connection with FIGS. 2A through 2F. A second dielectric layer **320**, preferably comprised of silicon dioxide, is formed over the first dielectric layer **322**. A third electrically conductive layer **324**, preferably comprising tungsten, is formed over the second dielectric layer **320**. A third adhesion layer **326**, preferably comprising a titanium-tungsten alloy is formed over the third electrically conductive layer **324**.

The third electrically conductive layer **324** and third adhesion layer **326** are formed into an upper switch contact **328** using conventional photoresist, masking and etching techniques, using an etchant which attacks the materials of the layers **324** and **326** but which is substantially unreactive with the material of layer **320**. The upper switch contact **328** preferably has a dumbbell (or dog bone) shape with expanded end portions **330** and a middle portion **332** as shown in FIG. 3B. The middle portion **332** of the upper switch contact **328** overlies the middle portion **314** of the middle contact **312** in substantially orthogonal relationship as shown in FIG. 3B.

Referring to FIG. 3C, a third electrically insulating layer **342** is formed over the second electrically insulating layer **320** and the upper switch contact **328**. In the preferred embodiment, the third electrically insulating layer **342** comprises silicon nitride. Holes **344** are opened in the third electrically insulating layer using conventional photoresist, masking and etching techniques, the etchant being the type which reacts with the silicon nitride material of the third insulating layer **342** at a more rapid rate than it reacts with the titanium-tungsten alloy material of the third adhesion layer **326** or the tungsten material of the third electrically conductive layer **324** or both. At the same time, small apertures **346** are opened in the third electrically insulating layer **342** down to the second electrically insulating layer **320** as shown in FIG. 3E. As shown in FIG. 3F, a void **348** is created in the first **322** and second **320** electrically insulating layers using an etchant which is introduced through apertures **346** and which reacts with the silicon dioxide material of the layers **320** and **322** and which is substantially unreactive with the materials of the third insulating layer **342** as well as the lower switch contact **316**, the middle switch contact **312** and the upper switch contact **328**. The middle contact **312** is floating since it is surrounded by the void **348**.

Referring now to FIGS. **4** and **5**, there is diagrammatically depicted an alternate preferred embodiment of the present invention where one of the electrical contacts is a cantilevered metal strip. This embodiment may be constructed as a single pole, single throw switch in accordance with the previous detailed description regarding FIGS. 2A through 2G; or it may be constructed as a single pole double throw switch in accordance with the previous detailed description regarding FIGS. 3A through 3F. In both of these embodiments, the cantilevered metal strips serve as the movable pole portion of the switch.

The single pole, single throw version of the electrostatic switch of the present invention, having a cantilevered metal strip as the pole, is preferably constructed in accordance with the previous detailed description regarding FIGS. 2A through 2E. However, when forming the second switch contact, which will be the cantilevered pole in this embodiment, a middle portion **600** will be defined and formed such that it has a contact region **602** at one end only as shown, for example, in FIG. 6, with the region **604** adjacent the other end in overlying relationship with the middle portion **606** of the underlying switch contact.. A void **608** is then formed between the two middle portions **600** and **606** preferably in accordance with the method for forming the void **238** as set forth in the previous detailed description.

The single pole, double throw version of the electrostatic switch of the present invention having a cantilevered metal strip as the pole is preferably constructed in accordance with the previous detailed description regarding FIGS. 3A through 3F. However, instead of the middle switch contact **312** having contact areas at each end as shown in FIG. 3B, the middle portion **700** (See FIG. 7) of the middle switch contact, or pole in this embodiment, is defined and formed such that it has a contact region **702** at one end only with the region **704** adjacent the other end in overlying relationship with the middle portion (not shown) of the lower switch contact and the middle portion **706** of the upper switch contact. A void **708** is then formed between the middle portion of the lower switch contact, the middle portion

600 of the cantilevered pole and the middle portion **606** of the upper switch contact, preferably in accordance with the method for forming the void **348** as set forth in the previous detailed description.

The operation of the electrostatic switch in accordance with the present invention is as follows. This operation is applicable to all of the embodiments described in the detailed description above. In other words, this operation is applicable to electrostatic switches in accordance with the present invention having a single pole, single throw configuration or a single pole, double throw configuration where the pole and switch contacts are secured at both ends; as well as single pole single throw and single pole double throw switches where the pole has a cantilevered configuration.

A potential is applied between the pole and a switch contact. In the preferred embodiment, this potential is as low as 25 volts if the spacing between the pole and the switch contact is on the order of 500 Å. Lower voltage operation can be employed with larger electrode spacings when longer floating metal conductors or lower modulus metals are used in the fabrication of these structures. The applied potential creates electrostatic forces between the pole and the switch contact causing the metal strip portion of the pole and the metal strip portion of the switch contact to deflect toward each other into contact in those embodiments where the middle portions are anchored at each end; and will cause the metal strip portion of the pole to deflect toward and into contact with the switch contact in those embodiments where the switch contact is secured along its length or where the pole is cantilevered. As previously stated, the voltage applied between the electrical contacts is high enough to create electrostatic forces sufficient to deflect the strip portion of the pole into electrical contact with the strip portion of the switch contact. The force between the intersecting bridges can be described by the parallel plate capacitor. Fringe fields will be ignored. Where

$$F = \frac{Q^2}{2E_0A} = \frac{E_0A}{2}\ \frac{v^2}{d^2} \qquad \text{(A)}$$

where

A=overlap area of metal 1/metal 2.

E_O=susceptibility 8.85×15^{12} coal^2/nt m^2

d=distance between metals 1 and 2.

V=voltage difference between metals **1** and **2**.

Q=charge in columbs.

For the deflection of a beam, $S_{\frac{1}{2}L}$ at the midpoint of its length under a concentrated load F where L=the length of the upper beam of metal **2**.

$$S_{\frac{1}{2}L} = \frac{FL^3}{4EWh^3} \qquad \text{(B)}$$

where

F=Beam loading force

E=Youngs Modulus

W=width of line **2**

h=height of line **2**

L=length of line 2 suspended in free space.

For metal line 2 with w/h=1, L=10 μm, E=10×10^9 Pa, h=1μ the following calculation will be performed for the force in (A) substituted into (B)

$$S_{\frac{1}{2}L} = \left(\frac{E_0A}{2}\ \frac{v^2}{d^2}\right)\frac{L^3}{4EWh^3} = \frac{E_0}{8}\ \frac{AL^3}{EWh^3}\left(\frac{v^2}{d^2}\right) \qquad \text{(C)}$$

Example: Using (c) and the following:

d=0.1 μm, L=10 μm, h=w=1 μm, A=(1 μm)^2, E=10×10^9 Pa

We get

$$S_{MAX} = \text{deflection at } \tfrac{1}{2}L \text{ of metal } 2 = 1.1 \times 10^{-7}\,\frac{\text{meters}}{\text{volts}^2}\,(v^2) \qquad \text{(D)}$$

for 100 volts held between metals **1** and **2**, metal **2** will flex and touch metal **1**. This will cause a link to form between the two metals and provide a conductive path for charge. If the spacing is reduced to 500 Å, the programming voltage is reduced to 25 volts.

Although the above description of the forces involved relate deflecting one electrical contact toward the other, this description is also applicable in the case of repulsive forces which can be applied between the middle contact means and one of the adjacent contact means in the single pole double throw embodiment whereby the middle contact means is repulsed from the one adjacent contact means and deflected toward and into contact with the other adjacent contact means.

In addition, although the above description and the figures show electrostatic switches constructed on one level, it would be apparent to those of ordinary skill in the art as a result of this detailed description that switches can be formed at multiple levels over the substrate and such is considered to be within the scope and contemplation of the present invention.

While the present invention has been described with reference to specific embodiments thereof, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the invention it is broader aspects. It is contemplated in the appended claims to cover all variations and modifications of the invention that come within the true spirit and scope of my invention.

I claim:

1. A method of fabricating an electrostatic switch on a substrate comprising the steps of:

a) forming a first layer of electrically conductive material over a surface of said substrate;

b) forming said first layer of electrically conductive material into a first electrical contact means;

c) forming a layer of electrically insulating material over said first electrical contact means;

d) forming a second layer of electrically conductive material over said layer of electrically insulating material;

e) forming said second layer of electrically conductive material into a second electrical contact means having a predetermined spaced relationship with respect to said first electrical contact means; and

f) creating a void in said layer of electrically insulating material between at least a portion of said first electrical contact means and said second electrical contact means.

2. The method in accordance with claim **1** wherein said substrate comprises a semiconductor substrate having electrical contact regions disposed therein, said method additionally comprising the steps of:

g) forming a first layer of electrically insulating material which is interposed between a surface of the semiconductor substrate and the overlying electrically insulating material;

h) forming at least one opening in said first layer of electrically insulating material to expose an underlying electrical contact region; and

i) forming said first layer of electrically conductive material over said first electrically insulating layer into said opening and into electrical contact with said exposed electrical contact region.

3. The method in accordance with claim 2 wherein step i) comprises the steps of:

(j) forming a first adhesion layer over the first layer of electrically insulating material into said opening and into electrical contact with said exposed electrical contact region; and

(k) forming a first electrically conductive layer over the first adhesion layer.

4. The method in accordance with claim 1 wherein step b) comprises forming said first layer of electrically conductive material into a first electrical contact means having a middle portion which is secured at least at each end to underlying structure; and wherein step e) comprises forming said second layer of electrically conductive material into a second electrical contact having a middle portion which overlies the middle portion of the first electrical contact means and which is secured at least at each end to said underlying second layer of electrically conductive material.

5. The method in accordance with claim 1 wherein step b) comprises forming said first layer of electrically conductive material into a first electrically contact means having a cantilevered middle portion which is secured at one end only to underlying structures; and wherein step e) comprises forming said second layer of electrically conductive means into a second electrical contact means having a middle portion which overlies said cantilevered middle portion of said first electrical contact means and which is secured at least at each end to said underlying layer of electrically insulating material.

6. The method in accordance with claim 1 additionally comprising, after step e), the steps of:

l) forming a second layer of electrically insulating material over said second electrical contact means;

m) forming a third layer of electrically conductive material over said second layer of said electrically insulating material;

n) forming said third layer of electrically conductive material into a third electrical contact means having predetermined space relationship with respect to the underlying first and second electrical contact means; and

o) creating a void in said layer of electrically insulating material and said second layer of electrically insulating material between at least a portion of said first, second and third electrical contact means.

7. The method in accordance with claim 6 wherein said second electrical contact means has a middle portion which is secured at least at both ends thereof to said underlying layer of electrically insulating material.

8. The method in accordance with claim 6 wherein said second electrical contact means has a middle portion which is secured at only one end thereof to said underlying layer of electrically insulating material.

* * * * *